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Socially Responsible Investment

A Multi-Criteria Decision Making Approach

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Foreword

To the memory of Professor Enrique Ballestero
Teacher, Colleague and Friend (Arganda del Rey 1928 – Madrid 2014, Spain)

The uprising social pressure on big companies to incorporate into their decision strategies elements of so-called corporate social responsibility is unquestionable. This fact has implications in many aspects of the business economics theory such as the portfolio selection problem. On the other hand, this new scenario considerably increases the analytical complexity of this type of problem since it requires the combination of conflicting criteria of different natures (financial, social and environmental criteria). This emerging situation makes a certain linkage of the classic portfolio selection problem to the multiple criteria decision making paradigm (MCDM) essential.

The issues expounded above motivated a group of distinguished researchers under the leadership of Professor Enrique Ballestero to join forces to prepare a manual that, combining clarity with scientific rigor, would present and critically assess the state of the art derived from the hybridization of portfolio selection and MCDM, within a corporate social responsibility context. Tragically, in the last stages of the book's preparation, the leader of the project, Professor Ballestero, suddenly passed away after a heart attack. The authors of the book have invited me to write a few lines glossing the human and intellectual figure of Enrique Ballestero. Really a difficult task because we are referring to a remarkable person with a highly versatile intellectual life. But in any case, the invitation is an honor for me and in the next lines I will try to provide a brief but balanced resemblance of this singular academic.

Professor Ballestero was a versatile and brilliant intellectual: teacher, economist, mathematician, Member of the Spanish Parliament (1979–1989), abstract painter, writer, etc. As an economist, he wrote around 20 books on different economic areas (business administration, accounting, appraisal techniques, etc.). His books were a perfect combination of scientific accuracy and an enormous clarity, always within the framework of a beautiful prose. To some extent, Professor Ballestero, as a writer always fulfilled the Popperian maxim: "every increment in clarity is of intellectual value in itself". Perhaps due to this perfect combination of clarity and rigor his books had an enormous influence on the education of a whole generation of young Spanish social scientists, to which I belong.

At the end of the 1980s, once he had left the Spanish Parliament, he started to research in the MCDM field, generating seminal contributions on it. Especially remarkable are his works linking the multi-criteria approach and economic analysis, developments in the stochastic goal programming method, providing a utility interpretation of the compromise programming model, extensions of the classic portfolio theory, etc. All these contributions were published in primary journals and were highly cited by the profession. I had the privilege of collaborating with Professor Ballestero on part of this research, which was mainly undertaken with a group of young and bright academics from the Technical University of Valencia (Alcoy School), many of them co-authors of the book that I am prefacing.

Since his youth, Professor Ballestero had a serious sight problem. He fought his near blindness with enormous courage, being an example of scientific enthusiasm and ethical behavior to all his disciples. He received several distinctions throughout his career. Recently, the Technical University of Valencia conferred him with its maximum distinctions, its Gold Medal and a "Doctorate Honoris Causa".

He was a convinced anglophile and very fond of good literature, so I have chosen the magical poetry of the following verses from a sonnet by the English poet Rupert Brooke to say farewell to a remarkable person:

> . . . he leaves a white
> Unbroken glory, a gathered radiance,
> A width, a shining peace, under the night

Enrique, rest in peace, and my eternal gratitude to you for your beneficial intellectual influence throughout my professional career, and especially from the first crucial stages. Not only when you supervised my doctoral dissertation with intelligence and generosity, but mainly when you taught me mathematics and economics at the end of the 1960s, as an undergraduate student, showing me not only how to understand these disciplines but also how to love them.

Madrid, Spain
June 2014

Carlos Romero

Preface

In the last 40 years, multicriteria methods have emerged as a branch of decision science. At the beginning of this period, the multicriteria tools did not seem convincing to those reviewers educated in the traditional paradigm, but years later the usefulness of multicriteria tools was undeniable. This intruding and welcome perception of their importance has caused some change in the decision-making map as well as in the optimization methods. For centuries, mathematicians have been interested in optimizing a single variable depending on other variables under constraints. This problem, elegantly solved by Lagrange in the eighteenth century, has a unique criterion character. Classic financial theory has insistently assumed this unique criterion of investing: to maximize the investor's wealth, or more precisely, to maximize the expected utility of wealth under uncertainty. Normative portfolio management models based on this assumption have been fertile in the past and are helpful for managers today, although psychologists and sociologists have commented their unrealism. One can argue that fund managers consider multiple criteria such as historical returns, market trends, conjectures about companies in the near future and in the long term, historical volatilities, downside risk, liquidity, expected changes in macromagnitudes, probability or likelihood of these changes, unpredictable events, appropriate size of portfolios and attractive image of portfolios to investors. Reducing all these criteria to a single variable seems quite impossible.

This book attempts to articulate socially responsible investments (SRI) into modern portfolio theory from the multicriteria perspective. Socially responsible Investment is a new deal defended by sectors of institutional investors and banks. These agents, which influence mutual funds and other collective investment schemes, think that financial strategies without ethical constraints can damage sustainable growth and welfare. To avoid this threat, they think that financial criteria such as profitability and risk should be combined with ethical criteria such as ecosystem protection, responsible consumption of energy, health care campaigns, no monopoly, no cartel agreements, and others. An increasing flow of financial resources should be invested in companies with ethical projects and a decreasing flow invested in companies with anti-ethical activities. Freedom but not government interventionism is a widely accepted principle of efficiency in Economics today, and therefore ethical investment is viewed as a private initiative.

As the title of this book suggests, the multiple criteria decision making methods play a visible role in this work. Some aspects should be highlighted. First, the overall approach of the book, except for some chapters at the beginning, is normative rather than descriptive. We emphasize the use of goal programming and compromise programming models to select ethical financial portfolios and evaluate fund performance. Second, applicability is a friendly purpose in the book. In every part of the book illustrative examples and actual cases are numerically developed. We think that theory alone is insufficient, not only to implement the methods, but also to get insight into them in a variety of details. Going from practice to theory is more natural and didactic than going from theory to practice. Third, we would be happy if the book is useful to graduates, researchers and practitioners as well as undergraduate students.

Thanks are given to Ignacio Gonzalez for reviewing the English style and grammar.

Finally, we would like to follow properly the path left by Prof. Ballestero, especially because of his interest in the increment and effective implementation of social responsibility in our society.

Thanks, Prof. Ballestero, for all you have taught us.

Alcoy, Spain Enrique Ballestero
Oviedo, Spain Blanca Pérez-Gladish
Alcoy, Spain Ana Garcia-Bernabeu
July 2014

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Part I
Critical Issues in Ethical Investment

Chapter 1
The Ethical Financial Question and the MCDM Framework

Enrique Ballestero, Blanca Pérez-Gladish, and Ana Garcia-Bernabeu

Abstract This chapter explains the financial meaning and importance of Socially Responsible Investment (SRI), also called ethical investment. Currently, SRI is a private initiative to invest increasing flows of financial resources in environmentally and socially sustainable activities and to invest nothing in anti-ethical projects. Main SRI agents are banks and institutional investors who are engaged in policies such as sustainable consumption of energy and natural resources, ecosystem protection, advanced medical projects, technological research, education of young entrepreneurs, anti-tobacco campaigns, safety and healthcare in the workplace, and others. These agents think that traditional financial criteria such as profitability and risk should be combined with SRI criteria to select stock portfolios. In SRI, Multiple Criteria Decision Making (MCDM) approaches seem to be helpful as several criteria, not only financial but also environmental, social or governance concerns are taken into account. Regarding MCDM, a brief overview is included in this chapter to introduce this methodology into SRI decision problems.

1.1 What SRI Means

Nowadays, the growing importance of social and environmental issues in our modern society cannot be denied or underestimated especially in the business world. The negative externalities of business are constantly increasing and concern more and more companies, civil society, consumers, investors, governments, media and international agencies. Moreover, many summits (Kyoto in 1997, Johannesburg in 2002, Copenhagen in 2009 and Durban in 2011), the development of credit rating agencies, the growing mobilization of NGOs, shareholder activism and social media demonstrate this growth of social and environmental concerns. Beyond this

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Table 1.1 The ten principles of the UN global compact

Area	Principle
Human Rights	**Principle 1.** Businesses should support and respect the protection of internationally proclaimed human rights **Principle 2.** Businesses should make sure that they are not complicit in human rights abuses
Labour	**Principle 3.** Businesses should uphold the freedom of association and the effective recognition of the right to collective bargaining **Principle 4.** Businesses should uphold the elimination of all forms of forced and compulsory labour **Principle 5.** Businesses should uphold the effective abolition of child labour **Principle 6.** Businesses should uphold the elimination of discrimination in respect of employment and occupation
Environment	**Principle 7.** Businesses should support a precautionary approach to environmental challenges **Principle 8.** Businesses should undertake initiatives to promote greater environmental responsibility **Principle 9.** Businesses should encourage the development and diffusion of environmentally friendly technologies
Anti-corruption	**Principle 10.** Businesses should work against corruption in all its forms, including extortion and bribery

Source: http://www.unglobalcompact.org/AboutTheGC/TheTenPrinciples/

growing concern about negative externalities, more and more stakeholders are also interested in the positive actions of business. Nowadays, no one denies that there are growing concerns regarding ethical aspects, that taking into account responsibility in finance is on the rise and that production of ethical reflection is booming. One can see more and more organizations adopting this approach of investment. In 2006 the UN, under the aegis of Kofi Annan, launched a number of principles for the responsible investment (Table 1.1). This initiative, according to Kofi Annan, was born from the increasingly obvious fact that, if finance is the engine of the global economy, investment decisions and shareholder practices do not reflect sufficiently considerations of social and environmental order. The UN's initiative advocated principles aimed at integrating environmental, social and governance issues (ESG) in the management of investment portfolios.

Although these principles imply voluntary compliance, it is worth stressing as well that they provide equally an official recognition of the role that ESG questions play in the financial sector and that they concern the totality of the financial securities, beyond the domain of Socially Responsible Investment (SRI).

In addition to the suggested principles, more than 30 possible actions have been envisaged. They concern a variety of issues, like investment decisions, shareholder activism, transparency, collaboration among signatories and the desire to monitor adoption of these practices by the entire financial sector. By adopting the principles, the institutional investors will be able not only to improve their capacity to honor their engagements to fund recipients, but also to better align their activities of investment with the broader interests of the company they have invested in, avoiding thus that their concern of performance requirements contributes to a crisis of values affecting communities.

Several observers have already stressed the growing importance of SRI (Renneboog et al. 2008). Moreover, the growing acceptance of SRI by several funds made the concept unavoidable. A number of pension funds have adopted the UN Principles. Just to mention a few, pension funds in Canada (Canada Pension Plan Investment Board, British Columbia Municipal Pension Plan, Caisse de Dépôt et Placements du Québec, etc.), as well as in the United States (New York City Employee Retirement System, United Church Foundation, etc.) and in France (Établissement du Régime Additionnel de la Fonction Publique, Fond de Réserve pour les Retraites, etc.), have adopted these principles. At the same time, mutual fund managers and managers of private wealth have also joined this movement. However, each one of these managers must follow the desires and specific values of their customer investor.

The definitions of SRI vary but also exhibit common traits. According to Weigand et al. (1996) SRI is a type of investment that takes into account ethical and social considerations, in addition to the traditional financial objectives in the selection of the securities integrating an investment portfolio.

SRI, also known as ethical investing, responsible investing, green investing, impact investing or sustainable investing, shares with conventional investing the top priority given to financial profitability, while considering in addition social, ethical or environmental parameters (Domini and Kinder 1984; Lowry 1993). Investors are thus obliged to make a choice of value and company (Judd 1990) reflecting their beliefs and their desire of change in the company. Argandoña and Sarsa (2000) recall that the principle of liberty informs each investment decision. Thus, beyond wealth maximization, according to the level of desired risk, any investor has a moral responsibility. This moral responsibility is exerted primarily throughout the choice of the companies in which he or she invests, according to negative criteria (firms with immoral activities) or positive criteria (to improve the behavior of the companies). Not all socially responsible investors try to change the world, the objectives of social changes are at the base of the ethical investing movement, aiming for example, to encourage the companies to undertake more responsible actions (Lowry 1993) or to support those which have already took some (Hutton et al. 1998).

Trying to find a common definition, the Forum for Sustainable and Responsible Investment (SIF, http://www.ussif.org) broadly defines Socially Responsible Investing (SRI), as an investment process that integrates environmental, social and governance (ESG) considerations into investment decision making to generate long-term competitive financial returns and positive societal impact. It is a process of identifying and investing in companies that meet certain standards of Corporate Social Responsibility (CSR).

Table 1.2 Main SRI strategies

Investment strategy	Description
Negative screening	It implies avoiding investing in companies whose products and business practices are harmful to individuals, communities, or the environment
Positive screening	It implies investing in profitable companies that make positive contributions to society, for example, that have good employer-employee relations, strong environmental practices, products that are safe and useful, and operations that respect human rights around the world
Community investment	It directs capital from investors and lenders to communities that are underserved by traditional financial services institutions. In the U.S. and around the world, community investing makes it possible for local organizations to provide financial services to low-income individuals and to supply capital for small businesses and vital community services, such as affordable housing, child care, and healthcare
Shareholder activism	It involves socially responsible investors who take an active role as the owners of corporate America. These efforts include talking (or "dialoguing") with companies on issues of social, environmental or governance concerns. Shareholder advocacy also frequently involves filing, and co-filing shareholder resolutions on such topics as corporate governance, climate change, political contributions, gender/racial discrimination, pollution, problem labour practices and a host of other issues. Shareholder resolutions are then presented for a vote to all owners of a corporation. The process of dialogue and filing shareholder resolutions generates investor pressure on company management, often garners media attention, and educates the public on social, environmental and labour issues. Such resolutions filed by SRI investors are aimed at improving company policies and practices, encouraging management to exercise good corporate citizenship and promoting long-term shareholder value and financial performance

Source: US SIF (2012)

The most widely used SRI strategy is screening. This investment strategy consists in checking companies for the presence or absence of certain social, environmental, ethical and/or good corporate governance characteristics. A description of the main SRI strategies can be found in Table 1.2.

Socially Responsible Investment has evolved from a marginal investment, followed by a few individual investors, to be a key investment for institutional investors and an investment of great interest to individual investors. Thus, today the influence of investors targeting socially responsible assets in capital markets cannot be overlooked. According to the US SIF Foundation's last report (US SIF, 2012): "from 2010 to 2012, sustainable and responsible investing enjoyed a growth rate of more than 22 percent. More than one out of every nine dollars under professional management in the United States today—11% of the $33.3 trillion in total assets under management tracked by Thomson Reuters Nelson—is involved in sustainable and responsible investing".

The motivations of socially responsible investors are diverse. They aim for strong financial performance but also believe that their investments should provide important societal or environmental benefits. These investors include, among others, individuals seeking to invest in companies with good ESG practices; credit unions and community development banks serving low-income and middle-income communities; foundations supporting community development loan funds and other high social impact investments in line with their missions; religious institutions filing shareholder resolutions to urge companies in their portfolios to meet strong ethical and governance standards; venture capitalists identifying and developing companies that provide social benefits; responsible property funds that help to develop residential and commercial buildings to high energy efficiency standards or public pension plan officials (http://www.ussif.org).

A large number of works can be found in the literature discussing the different motivations of socially responsible investors, as for example, Anand and Cowton (1993), Beal and Goyen (1998), Brammer and Pavelin (2006), Haigh (2007), Katz et al. (2001), Lewis and Mackenzie (2000a,b), McLachlan and Gardner (2004), O'Neil and Pienta (1994) and Rosen et al. (1991).

In 1971, Malkiel and Quandt (1971) published a work that suggests that the origins of modern SRI in the U.S. are the result of the concerns of the time about issues related to equal opportunities. These authors suggest that managers must take into account the political, social and moral consequences of their investing decisions.

Cowton (1989, 1992) noted the same idea, distinguishing between active and passive investors. Active investors use their actions to try to change business practices that are contrary to social responsibility. Passive investors simply avoid investing in companies with a socially irresponsible behavior. In the same spirit, Heard (1978) argues that socially responsible investors act according to the premise of the moral obligation of the companies not to cause harm to society.

Following the approach of Malkiel and Quandt (1971), Rudd (1981) argues that SRI seeks to promote activities that produce positive externalities for society and to reject those that involve negative externalities. Bruyn (1987) argues that SRI has traditionally been linked to the so-called "clean" products and has avoided activities related to alcohol, tobacco, pornography, gambling, weapons or military material.

Noreen (1988) defines ethical behavior as the relationship between economic agents by which certain attributes such as justice or truth, are revealed. Noreen's position is opposed to the fundamental premise of the agency theory and argues that agency costs are combined with social costs. According to Noreen socially responsible investors follow a utilitarian logic for investing ethically obtaining, on the one hand, utility from the financial return on investment and, secondly, from the sense of having "done well and done right." In view of this author, the behaviour of these investors is not altruistic. Altruism of SRI can be considered as a kind of philanthropy.

Finally, Noreen (1988) argues that SRI has three dimensions: ethics, aesthetics and selfish. He defines the "aesthetics" dimension as that which arises when the investor does not apply material, cultural or personal values in his investment decisions, for example, religious preferences of the manager of the company. The "selfish" dimension refers to those investments based on strong personal convictions about the companies that have no ethical or financial basis (for example, a union may invest in companies where unions play a very important role and stop investing in other companies that, in all other respects, are more socially responsible).

1.2 Historical Outline

The roots of the ethical financial movement are very old. In the Middle Ages, the Catholic Church forbade loans with interest or usury. By order of the Council of Nicaea I (325 BC), the clergy could not receive interest on their investments. A century later, the prohibition was extended to Catholic laypeople. In the eighth century, Emperor Charlemagne declared illegal and punishable lending with usurious interest. Later (fourteenth century) usurious loans were proscribed by Pope Clement V, negating any secular law authorizing them (Clavero 1985). One may believe that this policy did not favour the economic activity too much, but its ethical goal is undeniable.

Until the nineteenth century, the Catholic Church was the main promoter and manager of investment in public health and non-university education within the Latin area. The Catholic Church not only financed social investments with their own income, but also canalized a significant flow of rents to hospitals, nursing homes and schools. This shows that it is possible to raise awareness to invest ethically, sometimes giving up (at least to some extent) maximizing the financial return.

In Anglo-Saxon countries, the Quakers (Religious Society of Friends founded by George Fox in England in the seventeenth century and disseminated in the U.S. by William Penn) advised its members to invest with social criteria concordant with the ideas of peace, brotherhood and solidarity (Bjornsgaard 2011).

During the seventeenth and eighteenth centuries social purposes were developed by lenders in Italy, Spain and other countries. These institutions specialized in various solidarity financial activities (Miranda Boto 2009). They are treasury bills, deposits and pawnshops or pawn broking, whose history in Europe goes back to the fifteenth-century in Italy, although some precedents can be found in ancient Egypt. Pawn broking was oriented to various charity purposes: to stimulate people's savings, promote interest-free loans to poorer sections of the population and ensure minimum levels of social welfare.

Not all SRI initiatives have had continuity. Some ethical programs were abandoned or distorted over time becoming indeed conventional financial programs. In certain SRI initiatives, which had a respectable image, there was pressure from lobbies, power struggles, small-town politics, corruption and above all, an almost total absence of a real ethical motivation.

There are numerous studies on Spanish savings banks: credit social entities appearing in the nineteenth century with ethical and virtuous ideology (Fernández et al. 2009). The first Spanish savings bank was opened in Jerez de la Frontera in 1834 and its statutes embraced that ideology. Then, the savings banks began to operate as a combination of commercial banking and investment banking for the local or regional development.

However, the SRI movement did not fully develop until the late 1960s. It was the period of the Vietnam War (Marlin 1986), of an uncontrolled arms race, of major environmental damages without any protective legislation. It was also the period of protest marches on Washington calling for racial justice and equality (Malkiel and Quandt 1971). Movements in American universities against the war promoted divestment in companies that produced weapons, military electronics, etc. The great sensitization of the American public unleashed by participation in the Vietnam War (1959–1975) led to changes in investor sentiment, an example being the creation, on the initiative of the Methodists, of the Pax World Fund (1971). In the 1980s (Resolution of the UN General Assembly, 1980), largely due to protests against Apartheid in South Africa (Marlin 1986; Bloch and Lareau 1985), the concept of SRI begins to attract a larger group of American investors.

In Europe, the first ethical investment fund was the *Ansvar Aktiefond Sverige* created by the Swedish church in 1965. The case of UK is paradigmatic in developing SRI. At the beginning of its development the emphasis was on the Victorian social concerns about fair working conditions, and consequently, on local development and employment development, environmental criteria becoming more important later.

In 1984, an insurance company, Friends Provident, founded by two Quakers in 1832, launched the Stewardship Fund, a fund with social responsibility criteria. The ecological disasters of Bhopal (India, 1984), Chernobyl (Ukraine, 1986) and Exxon Valdez (Alaska, 1989) and the large amount of new information about global warming and the destruction of the ozone layer made environmental topics a top priority and a major social concern for investors (Renneboog et al. 2008).

In 1988 the Jupiter Merlin Ecology Fund was created. This fund is the pioneer among the so-called green funds that were created in the late 1980s based on principles of environmental sustainability. In the Netherlands, in 1990, ABF (Andere Beleggingsfonds) created at the initiative of religious groups and environmental organizations, the first socially responsible investment fund, the Het Andere Beleggingsfonds. Precedents in Holland go back to the 1960s and are materialized in the founding of banks: the ASN Bank in 1960 and Triodos Bank in 1980, both oriented to socially responsible savings products. In Finland, as in Sweden, it was the church that launched the first two ethical funds.

In Switzerland, the high associative and environmental awareness of citizens led to the emergence of two ethical banks: Freie Geminshafsbank (BCL) and the Alternative Bank Schweiz (ABS). Freie Geminshafsbank was founded in 1984 as a cooperative bank and its aim was to promote responsible sustainable non-profit projects, whether environmental, social or educational. The Alternative Bank Schweiz, created in 1990 conceived its activity as an alternative to the dominant economic logic with a policy that was based on innovation and responsibility. In its ethical ideology negative and positive criteria appeared that were subject to periodical review. The Alternative Bank Schweiz gave also credit to ecological, social and cultural projects.

In 1974 in Germany the GLS Gemeinschaftsbank AG appeared, which was considered the first ethical-ecological bank. In 2003 this bank merged with Ökobank, and it currently gives financial support to more than 3,300 social, environmental and cultural projects. Most of the granted loans were used for housing (18.7 %), social and education projects (13.6 %), renewable energy (12.4 %) and free and alternative education (11.8 %).

In the late 1980s the first ethical or socially responsible fund, the BfG Ökorent, was created with a clear environmental orientation. It is worth emphasizing the important role played by religious institutions as major institutional seekers of SRI in the German area.

In Austria, TOKOS, the first agency managing socially responsible assets appeared in 1991. At this time, the first magazine for the socially responsible investor (mainly ecological) Öko-Invest also appeared.

In France, the Committee Catholique contre la Faim et pour le Développement (CCFD) can be considered as the clearest precursor of SRI. Born in the early 1980s with the support of Crédit Coopératif, its vocation was to finance with part of its funds, business projects in developing countries. At this time the first mutual fund with an ethical or socially responsible profile arose, the Nouvelle Strategie Fund, created in 1983 by Nicole Reille. This investment fund with a social profile promoted the development of employment and the fight against social exclusion. In this sense, unions played a very active role in the introduction of social responsibility.

Finally, it is from the 1990s when an explosive growth in SRI occurs. A large number of indices appear: Domini 400 Social in 1990; Citizens Index in 1994; Natur Aktien Index in 1997; DJSI World Indices; Impax ET500 in 1999; Dow Jones Global Sustainability Index in 1999; FTSE4Good World Social Index in 2000; Calvert Social Index, Jantzi Social Index, Ethical Index Euro in 2000; DJSI STOXX, Ethical Index Global, ASPI Eurozone, FTSE4Good Indices in 2001; KLD Social Indices and ESI indices in 2002; KLD Nasdaq and Ethical Index Europe Small Cap and Kempen SNS Smaller Europe SRI Index in 2003 and FTSE4Good IBEX in 2008 are some examples.

In 1997, the UN launched the Global Reporting Initiative and from the 1990s several SRI forums were created all around the world to promote social responsibility in the investment processes: The Forum for Sustainable and Responsible Investment in the United States (US SIF) and its counterpart in Europe, EuroSIF, and previously, UKSIF in the UK (Cañal-Fernández and Caso 2013).

From this historical review we can see how the SRI concept has evolved throughout history and shows differences between countries that respond to the different motivations of investors and to cultural and legal questions. Anglo-Saxon and Nordic countries, including the Netherlands, give more importance to environmental values and ecology. In these countries, the development of a philosophy that puts the person in the center of economic activity and particularly values education, medicine and alternative therapies is also typical. Anglo-Saxon countries, mainly the UK, promote community development, particularly in marginal and depressed areas and job creation. Furthermore, they support social organizations to achieve the greatest presence and influence in Europe. In Mediterranean countries values such as solidarity and social inclusion of particularly marginalized groups are the most representative. We must also stress the role and power of the Catholic Church and the values it represents, as a unifying element in this area. Finally, countries like France, Belgium and Austria combined values of both areas, and also have specific characteristics such as the awareness of labor rights and the strong presence of unions

1.3 Why SRI? Sustainability Constraints in the Classical Economic Model

According to classical economic theory, social welfare is maximized in the long term when the following conditions are met:

(a) Freedom of the company.
(b) Competitive markets and more precisely, near-perfectly competitive markets.
(c) Open borders to traffic in goods and services, eliminating quotas, tariffs and export premiums.
(d) Unrestricted capital movements.
(e) Monetary Stability and flexible exchange rates.
(f) Balanced Budgets, minimizing public spending, taxation and the use of sovereign debt.
(g) Government neutrality regarding business activity, which means suppressing taxes on businesses, and at the same time, suppressing subsidies and favorable treatment to companies and sectors.

According to the classical economic theory, the activity of governments should be limited to the following:

(a) Guarantee private property, public order, public safety and freedom of trade.
(b) Promote Antitrust laws, preventing monopolistic practices.
(c) Ensure equal opportunities, facilitating the access of all citizens to education and health, though without interfering with or managing these services.

The classical liberal principles, accepted by economic theory, first appeared in the work of Adam Smith "The Wealth of Nations" published in 1776 (Smith 1776). Nevertheless, the analysis of the facts led to the suspicion that the conditions suggested by the classical theory for achieving social welfare were not enough. Various contrarieties were observed. First, there were the deviations from the equilibrium position. The process towards social welfare is not linear, but subject to significant fluctuations. Industrial crises, which were already analyzed by Sismondi in the nineteenth century, disrupt the process, appearing both unemployment and business instability. According to Sismondi, the classical principles of economics relate to welfare growth, but not to the growth of happiness. The equilibrium is reached only in the long term, after much suffering. This author claims: "Let us beware of this dangerous theory of equilibrium which is supposed to be automatically established. A certain kind of equilibrium, it is true, is reestablished in the long run, but it is after a frightful amount of suffering" (Sismondi 1991).

Secondly, the great depressions, as experienced by Western economies in 1929, generated social discontent, strikes and public disorder. In fact, the 1929 Great Depression led to totalitarian regimes which radically opposed to the principles of the economic programs following the classical theory. To explain the large depressions and combat them where possible, Keynes (2006) proposed a new analytical and normative model which was based on consumer behavior, saving versus real investment, the union influence on wages, and other economic and sociological variables. This model, which partially collected Sismondi's ideas, had an influence on the governments of Western countries during the twentieth century, but Keynesian policies have been abandoned so that in the twenty-first century most governments have returned to the classic principles.

Furthermore, the classical theory did not include the negative impacts of economic growth on the structure of planetary life. Industrial growth affected ecosystems and public health (diseases due to pollution, for example, see Miller and Spoolman (2011)).

And finally, other impacts are, e.g., low birth rates in some developed communities, with consequent loss of genetic capital (so-called "race suicide"); poor family relationships when family members work outside the home too long; disinterest in cultural investments that have little market demand; disinterest in that scientific research whose economic returns are uncertain, or if they occur, would occur in the very long term.

The SRI movement emerged more or less spontaneously in society to correct these deviations and negative impacts. Actually, SRI does not oppose movement conditions recommended by classical theory to achieve social welfare, but establishes that it is necessary to clarify them, because otherwise adverse effects previously presented would make difficult the process or would make it fail. Sustainable growth, as opposed to unrestricted growth, is a key idea in the present economy (Soubbotina 2004; Beckerman 2002).

1.4 Multiple Criteria Decision Making (MCDM) Framework

Multiple Criteria Decision Making (MCDM) includes a group of operational research methods pursuing making choices in the presence of multiple criteria, goals or objectives. MCDM models are a departure from the traditional operational research methods based on a single objective and are aimed at supporting decision makers (DM) faced with numerous and conflicting criteria.

1.4.1 A Brief MCDM History

MCDM started to emerge in the 1950s. The work of Charnes et al. (1955) established the essence of goal programming, although not using this name. In 1968, the same authors published the first book using the words "goal programming". MCDM has been an active area of research since the 1970s with important contributions due to Contini and Zionts (1968) and Zionts and Wallenius (1976). The paper written by Zionts (1979), entitled "MCDM – If not a Roman Numeral, then What?" was the responsible for using MCDM as accepted abbreviation of the field. Saaty (1977) introduced the Analytic Hierarchy Process (AHP), a multicriteria method that relies on pairwise comparison of criteria/assets to be evaluated from the decision maker's preferences

Keeney and Raiffa (1976) established the theory of multiattribute value theory (including utility theory) as a standard reference for decision analysis and MCDM.

In the late 1970s MCDM research focused on multiple objective mathematical programming problems, specially related to linear and discrete problems (Korhonen et al. 1984).

In 1972, Zeleny (1982) and Yu (1985) organized the First International Conference on MCDM at the University of Southern California. This conference was a turning point in MCDM.

MCDM has experienced a growing development from the 1990s until now and many subfields have emerged with a wide number of contributors that we do not include in this book. In 1992 Simon French edited the *Journal of Multi–Criteria Decision Analysis* aimed to be the repository of choice for papers covering all aspects of MCDA/MCDM. The journal provides an international forum for the presentation and discussion of all aspects of research, application and evaluation of multi-criteria decision analysis, and publishes material from a variety of disciplines and all schools of thought. Papers addressing mathematical, theoretical, and behavioural aspects are welcome, as are case studies, applications and evaluation of techniques and methodologies. A significant contribution to MCDM was Ballestero and Romero (1998) with their book "Multiple Criteria Decision Making and its Applications to Economic Problems". Relevant developments to the field of goal programming are due to Romero (1991), Ignizio (1976, 1985) and Lee (1972). A review of the early history of MCDM is made in Köksalan et al. (2013).

According to many authors, as for example Zimmermann (1992), MCDM is divided into multi-objective decision making (MODM) and multiattribute decision making (MADM). While MODM is related to problems in which the decision space is continuous, MADM is devoted to problems with discrete decision spaces. Continuous methods, pursues to identify an optimal quantity, which can vary infinitely in a decision problem. Linear programming (LP), goal programming (GP) and aspiration-based models are considered continuous. Discrete methods include weighting and ranking methods as for example, Multi-attribute value theory (MAVT), multi-attribute utility theory (MAUT) and Analytic Hierarchy Process (AHP).

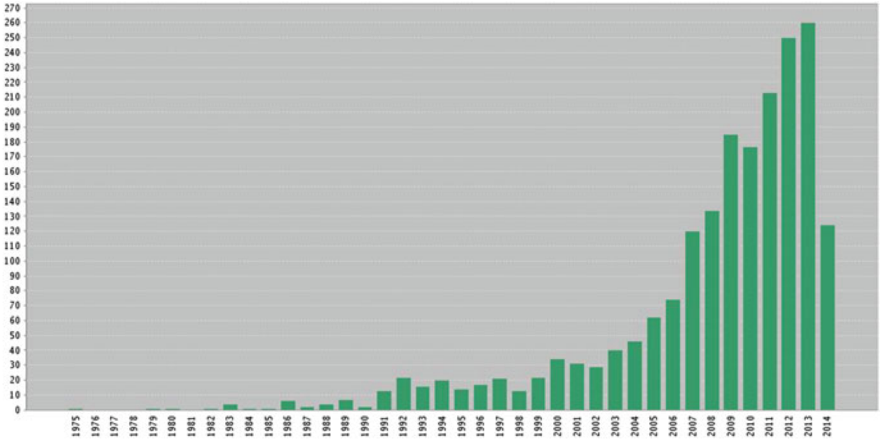

Fig. 1.1 MCDM published items in period 1950–2014 (Source: ISI Web of Knowledge)

MCDM draws upon knowledge in many fields including: Mathematics, Behavioral decision theory, Economics, Software engineering and Information systems.

We report basic statistics regarding how the field of MCDM has developed during the period 1950–2014. According to this database, the results of the search using "MCDM" keyword are 1968 publications in total.

In Fig. 1.1 the number of publications over the 1950–2014 period is shown. Growth in the number of publications has been significant during the last two decades.

There are several MCDM-related organizations including the International Society on Multi-criteria Decision Making, Euro Working Group on MCDA, and INFORMS Section on MCDM.

1.4.2 MCDM and Portfolio Selection

Financial decision making is in its nature a multiple criteria problem because it intends to balance between the conflicting objectives of minimizing risk and maximizing the financial performance of the portfolio.

Some recent works provided comprehensive revisions of the academic bibliography on MCDM techniques applied to portfolio selection, see for example, Zopounidis and Doumpos (2002, 2013), Steuer and Na (2003), Spronk et al. (2005), Xidonas and Psarras (2009), Xidonas et al. (2010), Azmi and Tamiz (2010), Metaxiotis and Liagkouras (2012), and Aouni et al. (2014).

Markowitz (1952) set the basis of the Modern Portfolio Theory in a mean variance framework based on historical returns. In this context, mean return and variance are used to estimate profitability and risk. Then, the portfolio selection problem is formulated as a quadratic optimization problem which is stated as the minimization of the risk, subject to a desirable level of return.

Early in the 1950s, the idea of determining Paretian efficient frontiers to select portfolios of stocks from mean-variance (E-V) optimisation was conceived by Markowitz (1952) as an operational research technique to model the investor's behaviour under risk. In those days, E-V efficient frontier was a departure from the principles of microeconomic analysis where uncertainty was almost dismissed in the approaches to investor's optimisation. Indeed, Markowitz felt frustrated by William's 1938 recommendation of choosing the security maximising the expected value of its discounted future dividend stream, since such a choice was made neglecting the risk problem. In contrast, E-V is a normative/descriptive model that relies on the classical well-founded financial utility theory of risk under uncertainty. These questions had been widely discussed by Tobin (1957), Borch (1969), Feldstein (1969), Levy (1974), Hanock and Levy (1969) and other authors.

Despite controversies, the applicability of E-V is not seriously hurt nowadays. An alternative, but not a substantially different model, is mean-absolute deviation (Konno and Yamazaki 1991). In those years, an advantage of using absolute deviation was to reduce the computational burden; however, this advantage is currently irrelevant as advances in computational software allow the analyst to solve a large-scale mean-variance problem in a few seconds. Other criteria/techniques used in portfolio selection are stochastic dominance (Copeland and Weston 1988, pp. 92–95) and skewness (Elton and Gruber 1984, pp. 236–238) "both of difficult applicability", as well as geometric mean maximisation (Elton and Gruber 1984, pp. 218–222) and "safety first" (Elton and Gruber 1984, pp. 222–229), which lead to efficient portfolios under precise conditions. Currently, the so-called "modern portfolio theory" follows a diversity of directions, including heuristic approaches (Balzer 1994; Sortino and Price Lee 1994; Nawrocki 1999), although E-V maintains its cornerstone position.

Several methods have been applied to the resolution of the portfolio selection problem. Among them, the most widely used is Goal Programming (Abdelaziz et al. 2007; Ballestero et al. 2012; Bilbao-Terol et al. 2013; Davies et al. 2009; Inuiguchi and Ramık 2000; Pendaraki et al. 2004; Prakash et al. 2003; Sharma et al. 2006; Tamiz et al. 2013) are some recent examples. From year 2000 a wide range of literature on MCDM approaches to portfolio choice and related issues is available. To cite but a few examples of this literature, we have the following papers.

1. New models relying on multiple objective programming (Steuer et al. 2005).
2. Extensions of the mean-variance model to include more criteria appealing to investors (Steuer et al. 2007).
3. Goal programming method to construct equity mutual fund portfolios (Pendaraki et al. 2004).
4. Integrating the decision maker's preferences into goal programming models by satisfaction functions given uncertainty (Aouni et al. 2005).

5. Fuzzy techniques are used to solve portfolio selection problems in Arenas Parra et al. (2001), Abdelaziz and Masri (2005), Perez Gladish et al. (2007), and Calvo et al. (2014).
6. Sharpe's betas with fuzzy information to undertake problems of portfolio choice are proposed in Bilbao-Terol et al. (2006) and Ballestero et al. (2009).
7. Linkages between compromise programming and utility theory are proposed to optimize efficient portfolios in Ballestero and Pla-Santamaria (2003) and Ballestero and Pla-Santamaria (2004, 2005).
8. A mean-semivariance model to determine efficient frontiers for portfolio selection with downside risk is proposed by Ballestero (2005).
9. Portfolio selection based on hybrid models and neural networks is developed in Ong et al. (2005), Huang et al. (2013) and Lin et al. (2009).
10. Stochastic programming is used for portfolio selection with multiple benchmarks in Bravo et al. (2010).
11. A stochastic programming model for portfolio selection in a framework of socially responsible investment is proposed by Ballestero et al. (2012), Bilbao-Terol et al. (2012, 2013), Cabello et al. (2014), Calvo et al. (2014), Dorfleitner et al. (2012), Drut (2010), Hallerbach et al. (2004), Steuer et al. (2007), and Utz et al. (2014).

1.4.3 MCDM Applications to SRI

The classical portfolio analysis assumes that investors are interested only in returns attached to specific levels of risk when selecting their portfolios. However, and despite the widespread use of the Markowitz framework (Markowitz 1952), there is an increasing acknowledgment among academics and practitioner, of the necessity of incorporating more criteria in the portfolio selection decision process, in order to better reflect the individual preferences of investors (Aouni 2009, 2010; Aouni et al. 2014). Therefore, a large number of works can be found combining the mean-variance framework with other measures characterizing the returns distribution. Briec and Kerstens (2010), Davies et al. (2009), Jondeau and Rockinger (2006), Kerstens et al. (2011), and Yu and Lee (2011) include among the considered criteria skewness and kurtosis. Other authors incorporate to the portfolio selection model risk measures as value at risk and conditional value at risk (Krink and Paterlini 2011; Mansini et al. 2007; Roman et al. 2007), the mean absolute deviation (Ogryczak 2000), and systematic risk (Rodríguez et al. 2011).

Conclusions

SRI has increased in recent years from being marginal and followed by a small number of investors to being a key investment tool for institutional investors and a highly attractive tool for individual investors. Currently, in more than 40

(continued)

countries worldwide including developing countries like Brazil, Morocco or South Africa, it is possible to invest in Socially Responsible Investment Funds that check the Corporate Social Responsibility of the companies in which they invest, in one way or another. The motivation and socio-demographic profile of socially responsible investors will be addressed in Chap. 2.

The growth in SRI has been accompanied by an increase in the number of scientific publications on the subject, most of which have focused on analysing if the social responsibility profile of an investment involves a financial cost in terms of profitability and risk. However, studies on the existence of a relationship between social performance and financial performance of SRI, do not reach unanimous conclusions. As we will see in Chap. 3, many works in the literature attempt to justify the lack of consensus on the results of these studies indicating that the main reasons relate to the definition of SRI, the differences in the methodologies, the lack of uniformity in the selected variables and the horizon and size of the samples used in the different empirical studies. Chapter 4 will be devoted to the discussion on the measurement of the social performance of the investment assets, with a special focus on the main SRI tool: socially responsible mutual funds. As will be shown, this is a key question which has to be addressed for the multicriteria socially responsible portfolio selection problem.

MCDM techniques have a relatively short history. Since 1950s and 1960s, when foundations of modern multi-criteria decision-making methods have been laid, many researches face problems from multiple criteria in many fields, such as, economics, finance or engineering. Portfolio selection has been a traditional MCDM problem and there is a growing interest in including the SRI dimension in classical financial decision making concerns.

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Chapter 2
Profiling Ethical Investors

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Abstract In the previous chapter we highlighted the important growth experienced by SRI especially remarkable after the 2008 financial crisis. In this context of growth it is important to know the profile of the important emerging group of investors willing to invest with social responsibility criteria, especially in countries like Spain, where this kind of investment is still marginal compared with countries like Australia which has a long SRI tradition. This chapter presents the results from a study designed to examine financial preferences, social, environmental, governance and ethical concerns and, socio-demographic characteristics and motivation of socially responsible investors. Based on an international online survey we analyse the degree of influence of a number of socio-demographic variables on the propensity for being a socially responsible investor. The study can be of great value for marketing researchers, institutional investors and fund managers attempting to identify those investors more receptive to SRI products. The information can also be used by advertising researchers to develop effective advertising campaigns.

2.1 Introduction

In the previous chapter we have seen how the SRI industry has experienced rapid growth in recent times. The presented figures indicate that the importance of the SRI industry is growing fast and is becoming a phenomenon that has to be taken seriously into account by both researchers and business experts (Nilsson 2008). However, factors leading investors to choose SRI products are not still

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well understood. As we have also seen in the previous chapter, we cannot find a precise and common definition of Socially Responsible Investing (SRI) as this concept depends on cultural and historical aspects. Therefore it is difficult to identify a homogeneous market for SRI: national markets vary considerably in terms of growth, investment strategies and asset allocation, and whether the investment is retail or institutional, which represents a challenge for both, investors and asset managers (EUROSIF 2012). Asset managers need to know the main characteristics of the national SRI markets in order to offer products depending on local investors' preferences. In this chapter we will focus on two markets with a different level of SRI development: the Australian and the Spanish markets.[1]

2.1.1 The Australian SRI Market

In Australia, the mainstream movement began in 1981 with the establishment of August Investment Proprietary Limited (in 1989, it became the Australian Ethical Investment Trust). In 1999, the Ethical Investment Association (EIA) was founded. Among other things, the EIA instigated a series of SRI benchmarking reports in Australia, supported by private stakeholders and the Australian Government Department of Environment and Heritage. The EIA changed its name in 2007, becoming the Responsible Investment Association Australasia (RIAA). Nowadays, in Australia, eight of the top ten investment managers have signed the UN Principles for Responsible Investment. In 2013, RIAA presented data on the state of the industry. Total funds under management in responsible investment portfolios at the end of 2012 totaled $152 billion, or approximately 16 % of total assets under management. Compared to 2011, responsible investment funds under management increased by 30 % in dollar terms, from $117 billion to $152 billion (RIAA 2013).

In Australia, ESG Integration has proven to be the dominant method of responsible investment, representing 89 % of the overall market total ($135 billion). ESG Integration has produced the largest growth, witnessing a 33 % increase in total funds under management between 2011 and 2012. Other approaches, such as community investments and sustainability themed investments, have also seen considerable growth in funds under management in the last year (19 and 16 % respectively), although they remain a relatively small portion of total responsible investments. The total number of funds that use a screening approach to investments, which includes most of the ethical funds, also showed a slight overall increase of funds under management of 2 %.

[1]This chapter is closely related to and heavily based on Pérez-Gladish et al. (2012) published in the Australian Journal of Management.

Corporate advocacy and shareholder engagement have not been yet taken into account widely in Australia. Nevertheless, proportionally, funds with corporate advocacy as a primary approach have increased by 33 %.

Most fund managers consider engagement with companies on ESG issues as an integrated part of their investment approach, but would not identify this as the primary responsible investment approach. Corporate advocacy investment strategies include portfolios that have been specifically constructed with the aim of influencing corporate behaviour with regard to ESG issues. Until recently these portfolios have attracted relatively small funds (RIAA 2013).

The RIAA also reports that relative to the general market, responsible investment funds have grown more strongly or fallen less sharply than the overall market in the post-global financial crisis period, highlighting their lower volatility and greater resilience in the face of tumultuous markets.

2.1.2 The Spanish SRI Market

In Spain, and according to EUROSIF (2012), all aspects of the economy have been affected by the 2008 economic recession, and the asset management industry has unsurprisingly not been immune to these negative shocks. The overall asset management market in Spain has seen total assets under management decline considerably over the past several years, triggered in large part by contagion effects from the global financial crisis of 2007–2008, as well as the steep corrections experienced in the overheated local housing and commercial real estate market. For instance, the total assets under management of the broader Spanish asset management industry have declined by over 31 % since their peak in 2007, when total assets under management reached 414.6 billion euros. The downward trend has continued over the past year as total assets declined by an additional 6 % to reach 284.7 billion euros at the close of 2011.

Despite this very difficult economic context, or perhaps because of it, the SRI market continues to gain traction in Spain. However, the Spanish market remains considerably less developed than many of its Northern European neighbours and continues to struggle to unleash the untapped potential that many analysts have been predicting for several years given the size and sophistication of the broader Spanish asset management industry. It remains a niche investment strategy dominated by a few large institutional investors, in particular large occupational pension funds.

Each of the different responsible investment strategies has demonstrated growth in Spain, a sign of the growing maturity of the market. Several strategies have in fact experienced a dramatic growth over the 2-year period from 2009 to 2011. For instance, the integration of ESG factors into financial analysis and engagement and voting strategies on sustainability matters have both seen their volume of activity more than double, when measured by the total assets under management they cover. The increased shareholder activism around ESG issues in Spain has been mainly driven by several big institutional players, including the two main trade unions and a number of large employers, particularly in the financial sector. As in previous years, the main issues targeted during the voting processes center around governance and executive compensation issues and less frequently touch upon the environmental and social stewardship of the targeted companies, although exceptions exist. Direct engagement with companies regarding ESG issues remains relatively underutilized in Spain, although it has been increasing in recent years. Indirect engagement with asset managers regarding their SRI investment practices is more common and is practiced by several large occupational pension funds.

While the Spanish SRI market has gained in sophistication in recent years, as evidenced by the increasing use of more complex strategies, exclusions of holdings remains the most common strategy, accounting for 56.2 billion euros in assets under management. Growth in the use of this strategy continues to be quite robust as the total assets under management employing this strategy has more than doubled since 2009. Weapons are the most common form of exclusion criteria in the Spanish SRI market, followed by vice exclusions such as pornography, tobacco, gambling and alcohol. The use of Norm-based exclusions has grown modestly in Spain but is used less widely than more traditional exclusions filters. Sustainability themed investment has grown slightly in recent years but remains a less widely used SRI strategy, although it is expected to gain in prominence in the near future.

While the overall responsible investment market in Spain remains small, it has shown surprising resilience given the poor performance in recent years of the overall asset management industry in Spain, as evidenced by the steep declines experienced among Spanish mutual and pension funds over the past several years. While over the past 2 year period there have been large gains in SRI market penetration, albeit from very low levels, these gains are due mainly to large and dramatic reductions in the volume size of mutual fund market in Spain, which fell from 163.2 billion euros in 2009 to 127.8 billion euros in 2011. Few commentators disagree on the fact that there is ample room for growth in Spain.

The Spanish responsible investment market is overwhelmingly dominated by large institutional investors who account for 97 % of total assets under management. Of these, by far the most active and dominant market participants are large occupational pension funds that remain the main drivers of the market in Spain. Retail specific SRI funds remain very marginal due in large part to a lack of interest and awareness from individual investors. This is not surprising given the risk profile of the average Spanish investor who tends to be very conservative, favouring fixed income and/or traditional bank deposits over equities. The recent growth of ethical banking options in Spain as well as the launching of several new retail SRI mutual funds is expected to jumpstart growth in the retail end of the SRI market in the mid-term. Nevertheless, it is not envisaged that the Spanish SRI market reaches the level of retail market penetration seen in other leading European countries (EUROSIF 2012).

2.2 Literature Review

Several studies have examined the demographics of socially responsible investors (SR-investors): gender, age, education, place of residence and income. These studies mostly refer to investors from countries where SRI is a well-established investment practice (i.e. UK, U.S. and Australia).

Rosen et al. (1991) used a mail survey of 4,000 investors in two US mutual funds that incorporate social screens in their investment decisions, the Calvert Social Investment Fund and the Working Assets Money Fund. In their sample, the average age of the SR-Investors was 39 years. They had median household annual incomes of $39,000. SR-Investors were mostly higher-degree educated, with 60 % having graduate degrees. Regarding employment, 81 % of SR-Investors are in white-collar jobs. Rosen et al. (1991) compared their results with those from an in-house 1986 study corresponding to conventional investors. SR-Investors were younger, better educated, but less affluent than the conventional investors.

More recently, Junkus and Berry (2010) survey a large group of US-based, well-informed, individual investors, members of the American Association of Individual Investors. They find that the typical SR-Investor is female and more likely to be single, younger, less wealthy, and better educated than their non-SR counterparts.

Woodward (2000) provided an analysis of SR-Investors and the criteria that these investors use as part of the investment decision process. It was based upon a questionnaire survey sent to two groups during the period October 1997 to January 1998. The first group consisted of 388 known SR-Investors. The second group consisted of 650 individuals drawn from a population of 2,421 potential investors who had requested a copy of the Holden Meehan Guide to Ethical Investment (1996). Woodward identified that a typical SR-Investor is likely to be middle aged, with over 78 % being between 36 and 65 years old. Further, they are highly qualified, as 83 % hold a first degree or higher academic qualification and 86 % are either professional or in managerial occupations. However, the annual income for over 60 % of these investors is less than £25,000 (data for 1996), which is a relatively low income level. Based upon the sample there is an approximately even gender split of SR-Investors – 52 % are male and 67 % of SR-Investors have children. Lewis and Mackenzie (2000) employed questionnaire data from 1,146 UK SR-Investors. Summarizing, their socio-demographic data showed SR-Investors are frequently middle-aged and middle-income professionals.

One of the issues studied by Nilsson (2008) was the relation between socio-demographic factors and the amount of investment in SRI mutual funds. Specifically, a questionnaire was answered by 439 SR-investors and 89 conventional Swedish investors. Gender showed a significant impact on how much was invested in SRI – men have a tendency to invest a smaller proportion in SRI. Education also proved a significant predictor of SR-investment behavior as consumers without a university degree invested less in SRI. The other three socio-demographic variables (income, place of residence, and age) did not significantly impact SR-Investors' behavior.

Several authors have studied the socio-demographic characteristics of SR-Investors in an Australian setting – including Beal and Goyen (1998), Haigh (2007), McLachlan and Gardner (2004), Tippet (2001), Williams (2007), and Pérez-Gladish et al. (2012). Beal and Goyen (1998) aimed to determine why people chose to invest in an Australian public nature conservation company "Earth Sanctuaries Ltd" (ESL), whose mission was to conserve ecosystems and to breed endangered species. A total of 825 investors were surveyed in their study. Their results show how ESL shareholders were generally older and more likely to be female than the total shareholder population. They were more likely to be metropolitan residents than regional and with significantly higher levels of education, socio-economic status and household assets.

Tippet (2001) used different groups of investors in his study: 122 responses came from members of the Australian Shareholders' Association, 57 responses came from clients of a private financial adviser specializing in ethical investment, and 79 responses came from members of the equity-investing Australian public. Their results showed that SR-Investors were more likely to be female (61 %) and tended to be younger (only 23 % were aged 55 years or more, and almost 40 % were much younger, aged between 35 and 44 years old). SR-Investors also showed to be better educated (77 % having a degree or higher degree qualifications).

In contrast, McLachlan and Gardner (2004) found no evidence of differences in age, education level, or income for Australian SR-Investors (based on a comparative examination of 55 conventional and 54 SR-Investors). However, conventional investors dominated SR-Investors in the two age categories at the extreme ends of range (16–25 and >65), while SR-Investors dominated conventional investors in the mid-range categories. Also SR-Investors were not found to have higher education levels than conventional investors. However, the modal pattern suggested that SR-Investors might have had somewhat higher education levels.

Pérez-Gladish et al. (2012) examine financial preferences; social, environmental and ethical concerns; and socio-demographic characteristics of Australian socially responsible investors. With the aid of an online survey and based on a sample of 145 investors they find that SR-Investors tend to be middle-aged, be middle-income professionals and have tertiary qualifications.

Other authors, as Williams (2007) or Haigh (2007) present cross-country studies. Williams (2007) includes in this work five countries: Australia, Canada, Germany, the UK and the US. Generally, the results showed demographic factors not to be significant. Income appeared to have some influence in Australia and Canada, but not elsewhere. Community size was important in Australia. Age appeared to be important in Germany, although the importance of social performance appears to increase with age, contrary to the author's hypothesis. Income appeared to be significant across all countries with SR-Investors having higher income levels than conventional investors. Overall, contrary to the findings of several studies (Rosen et al. 1991; Tippet 2001), in Williams (2007) demographics appear to explain very little and, in general, the results are not statistically significant, as in McLachlan and Gardner (2004). Getzner and Grabner-Kräuter (2004) find that SR-Investors tend to have higher levels of income and education.

Table 2.1 Main conclusions about socio-demographic characteristics of SR-Investors compared to conventional investors

Authors	Age	Gender	Income level	Educational level
Rosen et al. (1991)	Younger	Not statistically significant	Lower levels	Higher levels
Beal and Goyen (1998)	Older	Female	Higher levels	Higher levels
Tippet (2001)	Younger	Female	Not statistically significant	Higher levels
McLachlan and Gardner (2004)	Middle aged	Not statistically significant	Not statistically significant	Higher levels
Getzner and Grabner-Kräuter (2004)	Not statistically significant	Not statistically significant	Higher levels	Higher levels
Williams (2007)	Not statistically significant	Not statistically significant	Not statistically significant	Not statistically significant
Haigh (2007)	Not statistically significant	Male	Not statistically significant	Higher levels
Pérez-Gladish et al. (2012)	Middle aged	Not statistically significant	Middle income	Higher levels

Source: Own elaboration

Haigh (2007) used an internet questionnaire survey completed by 382 respondents, current and former social investors from Australasia, North America and Europe. His results were in line with previous literature findings. A slight majority of the respondents were male (55 %), while most were living alone (78 %). A range of ages was displayed (27 % under 35 years) and 68 % had completed a form of postgraduate education. More recently, Cañal-Fernández and Caso (2013) present a first preliminary study analyzing the individual investors' behavior in regard to the investment decision based on social responsibility criteria, establishing a classification of investors in Rational, Universal and Social investors. Using the online survey conducted in Spain in 2009 (see Pérez-Gladish et al. (2012) and the results of a Multiple Factor Analysis) they find that Spanish Social investors tend to be young men with higher education, with family responsibilities, religious, and with a middle income level. In this chapter we further exploit the results of the online survey comparing socio-demographic characteristics of socially responsible and conventional investors by means of a logistic regression. Table 2.1 summarizes the main conclusions about socio-demographic characteristics of SR-Investors compared to conventional investors.

The above results must be treated with caution given the heterogeneity of the characteristics of the studies: size of the sample, sample selection and countries. The present work tries to fill an existing gap in the literature concerning the socio-demographic profile of the Spanish SR-investors. We analyse the degree of influence of several demographic variables on SRI.

To build competitive advantage both in the short and in the long term, mutual fund managers need to know the characteristics of the market from both sides: demand and supply. Knowledge of the market, in particular of the demand characteristics, can aid in better achieving both strategic and tactical objectives. For strategic purposes, it can be used to prioritize market segment opportunities. For tactical purposes, it can help in implementing communication and advertising plans. In a market as the Spanish one where the presence of socially responsible investment is still marginal, information about the profile of investors is crucial.

As acknowledged by Spainsif (2012) two are the reasons for the scarce development of SRI in Spain: the limited supply of these financial products and the lack of knowledge on the part of the investors of these investment tools. As we have commented in the introduction, the majority of the SRI in Spain is conducted by the institutional investors. Nevertheless, as stated by Spainsif (2012), in the short term there is an important challenge for socially responsible asset managers: to attract retail investors overcoming the lack of confidence due to recent financial scandals and their traditional conservative profile. In this chapter we try to take a first step in this sense, examining the propensity of Spanish investors to invest in a Socially Responsible (SR) manner based on socio-demographic characteristics. The results will point up the relative size and characteristics of the segments most likely to be SR-Investors in two differently developed markets: the Australian and Spanish markets.

We will also try to contribute to the extant literature analyzing the influence of some new characteristics as the size of town or religion on SRI decisions. The proposed approach consists of a logistic regression which identifies important predictors of the dependent variable. This information can be of great value for marketing researchers, institutional investors and fund managers attempting to identify those investors more receptive to SRI products. The information can also be used by advertising researchers to develop effective advertising campaigns.

2.3 Research Design and Results

In order to profile SR-Investors, our research design has two main elements. We begin by implementing a broad-based survey aimed at collecting a representative sample across a wide variety of demographic characteristics of SR-Investors and non-SR investors. We then use these data in logistic regression analyses seeking to uncover the important dimensions of the SRI profile in a multivariate setting.

SR-Investors are a small but established and unique subset of the total investor universe. Although we compare the SR group with the non SR our main aim is to identify the characteristics and preferences of SR-Investors. Thus, the population of interest in our study is investors that already invest in SRI profiled funds or are willing to invest in them.

SRI mutual funds represent a small proportion of the total number of mutual funds and some mutual fund providers do not offer their customers any SRI funds

(Nilsson 2008). Hence, we could not randomly sample the general population since the number of SR-Investors is likely to be small compared with the general population of conventional investors, especially in the case of countries as Spain. To avoid this problem, we obtained our sample of investors via an online survey. Based on a literature review and discussions with experts in the field of SRI, a preliminary questionnaire was prepared. It was tested on market researchers and academic experts, incorporating comments/suggestions into the final questionnaire.

The questionnaire was self-designed by the authors with exception of questions relating to risk tolerance and the use of a financial advisor, for which we use the Ethical Investment Services Risk Profile questionnaire, kindly provided by Janice Carpenter, senior adviser.[2] It was designed to capture, for each respondent, their Social Environment and Governance concerns, their financial preferences including investment style, preferred investment characteristics and risk tolerance, and their demographic details. The questionnaire included 37 questions, grouped into three parts: (i) Socially Responsible Concerns, (ii) Financial Issues, including investment style, decision making style and risk tolerance and, (iii) Socio-demographic Information.

A logistic regression was done based on the obtained data (Pérez-Gladish et al. 2012). The issues covered in the questionnaire used in this paper are based on a review of the literature and discussion with industry representatives. Similarly, based on a literature review, we make predictions as to the relation between the fact of being a SR-Investor and the socio-demographic characteristics of the investors. These predictions are summarized in Table 2.2. We examine the four previously most studied demographic variables (age, gender, income level and educational level) found in the investment literature, and we include four more new variables: size of town of residence, marital status, number of dependent persons and religion. Table 2.2 displays the considered hypothesis in this study.

In order to control if a respondent is a SR-Investor or not we have introduced the following questions in the survey:

Q_1. Do you currently invest in socially responsible mutual funds?
Q_2. In case you answered no to the previous question, would you like any social, environmental or ethical issues to be taken into account when looking at your investments?

We are considering as SR-investors those answering "yes" to questions Q_1 or Q_2.

[2]Janice Carpenter is a Senior Financial Advisor at Ethical Investment Services. Janice is recognised as a key proponent of ethical investment in Australia. She has held a position on the board of the Australian Bush Heritage Trust and was Joint founding President of the Ethical Investment Association.

Table 2.2 Description of predictions

	Hypothesis	Authors
H_1	SR-Investors tend to be younger than non SR-Investors	Woodward (2000), Nilsson (2008), and Junkus and Berry (2010)
H_2	SR-Investors tend to be female	Beal and Goyen (1998), Junkus and Berry (2010)
H_3	SR-Investors tend to have higher income levels than non SR-Investors	Woodward (2000), Beal and Goyen (1998), Junkus and Berry (2010)
H_4	SR-Investors tend to be better educated than non SR-Investors	Woodward (2000), Nilsson (2008), Junkus and Berry (2010), Haigh (2007)
H_5	SR-Investors tend to live in metropolitan areas	Beal and Goyen (1998), Williams (2007)
H_6	SR-Investors tend to be married or with a partner	Junkus and Berry (2010)
H_7	SR-Investors tend to have dependent people	Woodward (2000)
H_8	SR-Investors tend to be more religious persons than non SR-Investors	Peifer (2011)
H_9	SR-Investors tend to be more concerned by SEG issues than non SR-Investors	Rosen et al. (1991), Nilsson (2008), Woodward (2000), Anand and Cowton (1993), McLachlan and Gardner (2004)
H_{10}	The more socially responsible the investor is, the more likely they have a positive or inclusionary investment strategy	Haigh (2007)
H_{11}	SR-Investors tend to avoid some particular holdings in particular companies.	Anand and Cowton (1993)
H_{12}	SR-Investors tend to avoid some particular holdings in particular industries	Anand and Cowton (1993)
H_{13}	SR-Investors tend to avoid some particular holdings in particular countries	Anand and Cowton (1993)
H_{14}	SR-Investors are more likely to invest in domestic assets	SIF (2010)
H_{15}	SR-Investors tend to visit more financial advisors	Haigh (2007)
H_{16}	SR-Investors tend to be concerned about both, financial and non-financial characteristics of their investments.	McLachlan and Gardner (2004), Lewis and Mackenzie (2000), Nilsson (2008), Woodward (2000)
H_{17}	SR-Investors tend to be more conscious of capital growth vs. income characteristics	Woodward (2000)
H_{18}	SR-Investors tend to be more risk tolerant	Nilsson (2008), Williams (2007), Haigh (2007), Beal and Goyen (1998)

2.4 Case Studies for the Spanish and the Australian Investors

In this chapter we try to take a first step examining the propensity of Spanish investors to invest in a Socially Responsible (SR) manner based on socio-demographic characteristics. The results will show the relative size and characteristics of the segments most likely to be SR-Investors in two differently developed markets: the Australian and Spanish markets.

2.4.1 Spanish Investors

The link for the online survey in Spain was displayed on the Spanish Morningstar website from November 2008 to July 2012. We obtained 230 usable questionnaire responses from SR-Investors and 67 usable questionnaire responses from non SR-Investors.[3]

2.4.1.1 Descriptive Statistics

The study was based on a survey of 214 individuals, who filled out an online questionnaire which they accessed through a banner on www.mornigstar.es. The survey included items regarding investment habits, personal preferences and attitudes toward social, ethical and environmental issues. As for the investor's socio-demographic profile, we should point out that 82.2 % were men; 70.9 % were married or with a partner; 54,0 % had no dependents; 84.1 % had university education; 59.8 % were between 25 and 50 years old and 31.3 % between 51 and 65; 64.1 % declared themselves Catholics; 89.2 % had a higher than average[4] net disposable income; and, in terms of residence, 28.0 % lived in a periphery small city,[5] 24.3 % in a big size city[6] (Madrid) and 24.3 % in a central small city.[7]

A very low percentage of the sample (8.5 %) declared to be a socially responsible investor (SRI), most of whom (85.7 %) invested below 50 % of their investment budget in socially responsible funds (SRF). The main reasons for not investing in SRF are lack of information regarding this kind of products (51.5 %) and the belief that they provide lower financial returns (22.2 %).

Nevertheless, as many as 3 out of 4 individuals stated that they would like social, ethical or environmental issues taken into account when looking at their investments and 23.0 % of them would be willing to invest above 50 % in SRF. Participants were asked to assign a value to these issues, ranging from 1 (not at all concerned) to

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[3] We acknowledge that there could be a sample selection bias. Investors who are committed to SRI are more likely to respond. Given that the focus of our study is to profile this group, selection bias is not likely to present a major problem for us.

[4] 18,941.00 € (source: http://stats.oecde.org).

[5] Less than 500,000 inhabitants and located more than an hour drive away from a big or medium-sized city.

[6] Above 2.5 million inhabitants.

[7] Less than 500,000 inhabitants and located less than an hour drive away from a big or medium-sized city.

5 (extremely concerned), and results show that the ones that matter the most to Spanish investors are chemicals of concern (4.32), bribery and corruption (4.30), water pollution (4.26), training and development (4.19), human rights (4.11) and access to medicines in developing countries (4.04). At the bottom of the list are gambling (2.27), women on corporate boards (2.38), trade unions (2.50) and tobacco marketing (2.58).

As for investment strategies, 50.0 % of respondents declared not having one, while 13.0 % say they have a strategy of exclusion and 14 % defined theirs as a strategy of inclusion, the rest having a combination of strategies. 24.2 % would exclude certain companies from their investment portfolio and a very similar percentage would exclude specific regions or countries (26.3 %), mainly those which have non-democratic governments. As many as 30.8 % would exclude specific economic sectors, mainly mining, although it must be pointed out that a large number of participants mentioned the military sector and the weapon industry under the "Others" option.

Out of the 87.7 % who would like to invest in domestic assets, 70.0 % would do so with less than 50 % of their investment budget and 25.0 % with 50–75 % of it. 39.3 % of participants compare potential investments in order to choose those which provide good value for their price, whilst 17.8 % have high expectations and actively seek the highest quality products and 11.2 % focus on companies with well-known reputation. When looking for an investment, the factors that are most important[8] to Spanish investors are the fund manager's reputation (4.36), exit (4.05) and initial fees (4.05). On the contrary, they are less concerned about fund size (3.20) and past performance (3.25).

Respondents who want their investment to provide long term capital growth account for 42.5 and 47.2 % look for a regular income in addition to that.

The questionnaire included a section in which participants had to position themselves regarding several statements, and results obtained indicate that 61.6 % would put their investment budget in cash to protect the value of their savings, 51.6 % would set security above higher returns and 57.3 % expect most of their investments to be in place for more than 3 years.

As few as 7.0 % claimed that investing in shares is not for them as a consequence of the risks involved and 72.9 % stated that they do not mind seeing their investment fall in value for a year or more, provided the long-term return is good, which is endorsed by those who say they would keep an investment which is part of a long term strategy (5 years plus) even if it lost 15 % or more of its value in a year (58.9 %).

The majority of respondents were individual investors (96.6 %) and only 3.4 % were institutional investors. More than half of the participants (57.5 %) described their understanding of investment markets as good and one third said it is reasonable. When asked about the usual way through which initial contact is made to make an investment, 58.2 % answered it is Internet and, 27.7 % visits to an investment

[8]They were asked to pick a value from a scale ranging from 1 (not important) to 5 (essential) and average values were calculated for all factors in order to establish the order of importance.

advisor. This difference increases when the question refers to the preferred way to conduct investment transactions once first contact has been made, since 82.5 % selected Internet, versus 12.7 % who chose visits to an investment advisor.

2.4.1.2 Statistical Results: Logistic Regression

In what follows we will present the results of a logistic regression which identifies important predictors of the dependent variable: "Socially Responsible Investment Behavior". This variable is defined as a dummy variable to represent two groups:

$$SRI_i \begin{cases} 1 & \text{if the respondent investor would like to invest more that 50 \%} \\ & \text{of his/her budget in SR funds} \\ 0 & \text{otherwise} \end{cases}$$

We consider three key groups of factors influencing SRI behaviour:

- A group of socio-demographic variables
- A group of financial variables
- A group of Social, Environmental and Governance (SEG) variables

A Group of Socio-demographic Variables

The survey questions related to socio-demographic considerations are described using dummy variables or ordered categorical variables as follows:

$$D_{Bcityi} = \begin{cases} 1 & \text{respondents who live in a big city} \\ 0 & \text{otherwise} \end{cases}$$

$$D_{Femi} = \begin{cases} 1 & \text{respondents who are female} \\ 0 & \text{otherwise} \end{cases}$$

$$D_{Mari} = \begin{cases} 1 & \text{respondents who are married} \\ 0 & \text{otherwise} \end{cases}$$

$$D_{Depi} = \begin{cases} 1 & \text{respondents who are dependents} \\ 0 & \text{otherwise} \end{cases}$$

$$D_{unii} = \begin{cases} 1 & \text{respondents who have studied at university} \\ 0 & \text{otherwise} \end{cases}$$

$$D_{RELi} = \begin{cases} 1 & \text{respondents who are religious} \\ 0 & \text{otherwise} \end{cases}$$

$$AGE_i = \begin{cases} 0 & \text{under 25 years} \\ 1 & \text{25–50 years} \\ 2 & \text{51–65 years} \\ 3 & \text{over 65 years} \end{cases}$$

$$ING_i = \begin{cases} 0 & \text{below average} \\ 1 & \text{average} \\ 2 & \text{above average} \end{cases}$$

A Group of Social, Environmental and Governance (SEG) Variables

Social, environmental and governance concerns are disregarded from 37 items on the questionnaire. The extraction of principal components to reduce the number of variables results in four proxy variables. Eigenvalues for components 1, 2, 3 and 4 were 22.3, 1.84, 1.40 and 1.19 respectively. Selecting four components allows 72.30 % of the variance to be explained. We denote these components as: SEE_{PC1}; SEE_{PC2}; SEE_{PC3} and SEE_{PC4}.

Five components were initially selected but we decided to consider only the two first components which represent 65.26 % of the variance and can be easily interpreted. The incorporation of the other components does not provide a significant increment of the explanation of the variance.

All SEG concerns load positively onto the first component, explaining 60.27 % of the variance. Reference to the various loadings suggests that this variable can be interpreted as an *environmental-ethical oriented* factor, with the highest loadings on nuclear power; environmental management, policy, reporting and performance; pollution and water pollution within the environmental dimension, and aboriginal land rights; equal opportunities, and intensive farming and meat sale within the ethical dimension.

The second component covers *social/health* issues, the most relevant SEG concerns for this component being: Contraception; Breast milk substitutes; Military issues; Gambling; Animal Testing; Abortion; Alcohol and Tobacco marketing.

A Group of Financial Variables

Incorporating investor preferences for return, risk and types of investment. In what follows we present the factors included into the financial considerations:

(i) *Investment strategy/screening process.* A specific survey question asked whether respondents adopt an inclusionary (positive) or exclusionary (negative) investment style. Accordingly, two dummy variables are created.

An alternative way to consider an exclusionary/inclusionary style is to capture the extent to which the investor would screen in terms of company, region or sector. Therefore, three additional dummy variables are created, $DSCom_i$, $DSReg_i$ and $DSSec_i$:

$$D_{Inci} = \begin{cases} 1 & \text{respondents who have an inclusionary investment style} \\ 0 & \text{otherwise} \end{cases}$$

$$D_{Exci} = \begin{cases} 1 & \text{respondents who have an exclusionary investment style} \\ 0 & \text{otherwise} \end{cases}$$

$$D_{SComi} = \begin{cases} 1 & \text{respondents who have an exclusionary investment style} \\ & \text{for companies} \\ 0 & \text{otherwise} \end{cases}$$

$$D_{SRegi} = \begin{cases} 1 & \text{respondents who have an exclusionary investment style} \\ & \text{for regions} \\ 0 & \text{otherwise} \end{cases}$$

$$D_{Seci} = \begin{cases} 1 & \text{respondents who have an exclusionary investment style} \\ & \text{for sectors} \\ 0 & \text{otherwise} \end{cases}$$

(ii) *Decision-making style:* To capture the respondents' decision-making style, a dummy variable is created to reflect if the investor has difficulties when making choices and seeks help or not:

$$D_{Helpi} = \begin{cases} 1 & \text{investors seek help when making choices} \\ 0 & \text{otherwise} \end{cases}$$

(iii) *Investment characteristics:* An ordered categorical variable (*DOM*) is created to reflect the percentage of the investment budget investors would include in domestic assets:

$$DOMi = \begin{cases} 0 & \text{those that invest 0–25 \% of their budget in domestic assets} \\ 1 & \text{those that invest 25–50 \% of their budget in domestic assets} \\ 2 & \text{those that invest 50–75 \% of their budget in domestic assets} \\ 3 & \text{those that invest 75–100 \% of their budget in domestic assets} \end{cases}$$

Nine alternative characteristics of funds (relating to performance, reputation, fees, age and size) were presented to respondents for them to identify which are important to them when looking for an investment. A PCA is performed on the nine items. The first component has an eigenvalue of 4.3 and explains 43.47 % of the variance. The second and third components have eigenvalues of 1.6 and 1.4, respectively, and all three together explain 74.23 % of the variance.

Accordingly, three variables are created: $InvC_{PC1}$, $InvC_{PC2}$ and $InvC_{PC3.}$. The first component is essentially a general fund variable with a focus on fees and reputation. The second component is a performance variable, while the third represents age and size of the fund.

Two dummy variables are created to reflect desired growth/income characteristics of the investment:

$$D_{LTGi} = \begin{cases} 1 & \text{respondent wants investments to provide long-term} \\ & \text{capital growth} \\ 0 & \text{otherwise} \end{cases}$$

$$D_{GIi} = \begin{cases} 1 & \text{investor wants his investments to provide both} \\ & \text{growth/income} \\ 0 & \text{otherwise} \end{cases}$$

(iv) *Risk profile:* A risk tolerance variable (*RTol*) is created using PCA on the three survey questions that address the investor's preferences to invest in cash, risk versus higher returns, and views on the riskiness of share investments. The responses to the three questions are reduced to one variable, given by the first principal component (the eigenvalue on the first component was 1.4 and explains 46.52 % of the variance).

Respondents were asked to self-assess their understanding of investment markets. Based on the responses, an ordered categorical variable *UNDIM* is created (0, 1, 2, 3, 4), increasing in their level of understanding (where 0 = no understanding through to 4 = excellent understanding). This variable is used as a control in assessing the relevance of risk tolerance levels to investment decisions.

(v) *Investment horizon:* An ordered categorical variable *HOR* taking values from 0 to 4, representing the investment horizon, where 0 = less than 2 years; 1 = 2–3 years; 2 = 3–5 years; 3 = 5–7 years and 4 =>7 years. The investor's long-term investment focus L_{TERM1} is captured using an ordered categorical variable (0–4) where 0 (4) represents those investors strongly agreeing (strongly disagreeing) that they would not mind a short-term loss providing the long-term return is good. Similarly, those willing to keep an investment as part of a long-term strategy, even if there was a short-term loss (15 % or more in a year) allows the creation of an additional ordered categorical variable (0–4) L_{TERM2}.

Table 2.3 summarizes the results obtained for different *logit* analysis with the aim of evaluating the influence of the different variables on the Spanish socially responsible investor profiles. All the models include demographic variables as control variables. Independent variables are displayed in the first column and the obtained coefficients are shown in the second column with the corresponding p-value within parentheses as well as the odds ratio for those cases in which they are significant.

Table 2.3 Regression results for Spanish investors

Regression 1: Demographics		Regression 2: SEG concerns		Regression 3: Investment style (a)		Regression 4: Investment style (b)		Regression 5: Growth-/income		Regression 6: Risk tolerance	
Ind V	Est.Coe.	Ind V	Est.Coe.	Ind V	Est.Coe.	Ind V	Est.Coe.	Ind V	Est.Coe.	Ind V	Est.Coe.
β	−1.081	β	−1.436	β	−1.108	β	−1.172	β	−0.803	β	−1.432
	(0.186)		(0.154)		(0.178)		(0.180)		(0.412)		(0.222)
INC	−0.476	INC	−0.302	INC	−0.470	INC	−0.395	INC	−0.539	INC	−0.340
	(0.108)		(0.409)		(0.114)		(0.193)		(0.087) (0.583)		(0.271)
AGE	0.728	AGE	0.779	AGE	0.733	AGE	0.858	AGE	0.664	AGE	0.824
	(0.005) (2.071)		(0.016) (2.180)		(0.004) (2.082)		(0.002) (2.359)		(0.020) (1.942)		(0.003) (2.280)
D_{BCity}	0.033	D_{BCity}	0.001	D_{BCity}	0.022	D_{BCity}	−0.086	D_{BCity}	0.121	D_{BCity}	0.221
	(0.934)		(0.998)		(0.956)		(0.837)		(0.776)		(0.606)
D_{Uni}	−0.577	D_{Uni}	−0.390	D_{Uni}	−0.579	D_{Uni}	−0.479	D_{Uni}	−0.377	D_{Uni}	−0.411
	(0.186)		(0.486)		(0.187)		(0.291)		(0.421)		(0.372)
D_{Dep}	−0.073	D_{Dep}	−0.275	D_{Dep}	−0.071	D_{Dep}	−0.066	D_{Dep}	0.125	D_{Dep}	−0.043
	(0.833)		(0.526)		(0.838)		(0.853)		(0.728) (2.071)		(0.958)
D_{Rel}	−0.585	D_{Rel}	−0.748	D_{Rel}	−0.592	D_{Rel}	−0.510	D_{Rel}	−0.749	D_{Rel}	−0.521
	(0.089) (0.557)		(0.096) (0.473)		(0.086) (0.553)		(0.154)		(0.042) (0.473)		(0.149)
D_{Fem}	0.978	D_{Fem}	1.127	D_{Fem}	0.983	D_{Fem}	1.031	D_{Fem}	0.960	D_{Fem}	0.841
	(0.024) (2.658)		(0.031) (3.086)		(0.024) (2.671)		(0.022) (2.804)		(0.033) (2.613)		(0.085) (2.319)

(continued)

Table 2.3 (continued)

Regression 1: Demographics		Regression 2: SEG concerns		Regression 3: Investment style (a)		Regression 4: Investment style (b)		Regression 5: Growth-/income		Regression 6: Risk tolerance	
D_{Mar}	0.342	D_{Mar}	0.035	D_{Mar}	0.335	D_{Mar}	0.448	D_{Mar}	0.497	D_{Mar}	0.324
	(0.392)		(0.942)		(0.403)		(0.282)		(0.240)		(0.433)
		SEE_{PC1}	0.550	D_{Exc}	0.019	D_{SCom}	0.440	D_{Help}	0.936	RTol	−0.276
			(0.029) (1.734)		(0.975)		(0.345)		(0.072) (2.551)		(0.211)
		SEE_{PC2}	0.699	D_{Inc}	0.181	D_{SReg}	−0.672	D_{LTG}	−0.805	U_{NDIM}	0.169
			(0.002) (2.012)		(0.739)		(0.155)		(0.447)		(0.460)
						D_{SSec}	−0.672	D_{GI}	−0.418	HOR	−0.431
							(0.155)		(0.500)		(0.017) (0.650)
						DOM	−0.343	$InvC_{PC1}$	0.010	LT_{erm1}	0.145
							(0.111)		(0.959)		(0.488)
								$InvC_{PC2}$	0.384	LT_{erm2}	−0.081
									(0.041) (1.468)		(0.694)
								$InvC_{PC3}$	0.030		
									(0.871)		
R^2 p–val	0.13 19.137 0.014	R^2 p–val	0.227 25.678 0.004	R^2 p–val	0.131 19.246 0.037	R^2 p–val	0.178 25.822 0.011	R^2 p–val	0.167 24.263 0.043	R^2 p–val	0.221 33.491 0.001

This table presents the results from the logistic analysis. The dependent variable is SRI, an dummy variable where $SRI_i = 1$ for those that invest more than 50 % of their budget in socially responsible funds and $SRI_i = 0$ otherwise. The independent variables are specified in the first column of each pair of columns. The coefficients are reported with the p-value in parentheses

The first regression (**Regression 1**) includes only the demographic variables. We can observe that only three variables: age, sex and religion are significant at levels 1, 5 and 10 % respectively. If we observe the coefficients, only for the variable sex the sign is the predicted. This confirms that being a woman is positively related to being socially responsible. Analysing the odds ratio, women have triple possibilities of being socially responsible compared with men (2.658). Religion has an estimated negative coefficient which means that religious investors are less likely to invest in socially responsible mutual funds. The possibility of being socially responsible is reduced by 0.557 in the case of religious investors. The positive coefficient of the variable age suggests that older investors are more likely to be socially responsible than young investors (twice as much). The set of demographic variables is considered as a set of control variables for the remaining regressions.

In the second regression model (**Regression 2**) the demographic variables are combined with variables SEE_{PC1}, SEE_{PC2} obtained from the Principal Component Analysis which summarizes the 37 questions related to SEG concerns. The obtained results show how age, sex and religion maintain their relevance and that SEG_{PC1} and SEG_{PC2} are significant variables at level 5 %. In both cases, the positive expected relation is obtained. These two components reflect environmental-ethical and social-health related investors' concerns.

Regression 3 combines the demographic variables with the investment style, that is, it takes into account if the investor follows an inclusive or exclusive investment strategy. In this case we see how the demographic variable age, sex and religion retain their significance. However, we found that the style (inclusive or exclusive investment) is not significant and, therefore, is not associated with being socially responsible or not.

In **Regression 4**, we differentiate between exclusionary strategies that discriminate by country, region or sector and we include a variable reflecting the level of domestic investments. Again, the obtained results confirm that socially responsible investors in this sample do not follow an exclusionary strategy of any kind and are not interested in investing in domestic assets.

In **Regression 5**, variables are included in the specification to analyse socially responsible behaviour in relation to whether or not respondents need advice in their investment decision making process; the expected outcome of the long-term growth investments or a combination growth and regular income; and the three principal components extracted from the investment characteristics (InvCPC1; InvCPC2; InvCPC3). This regression analysis shows that demographic variables age, sex and religion remain relevant together with this group the variable income significant at 10 % and with a negative influence, indicating that higher-income investors are inclined to a lesser extent for socially responsible investing. The advice when making an investment is a significant variable at 10 % having a positive impact. Investors seeking advice are 2.551 times more likely to invest in socially responsible funds than investors who do not seek financial advice when investing. The second component related to financial performance has a positive influence on socially responsible investing. Investors who pay special attention to the financial results have a propensity 1.468 times higher to invest in socially responsible funds than investors who do not pay attention to those results.

Finally, **Regression 6** incorporates demographic variables, risk tolerance (*RTOL*), knowledge of financial markets, the investment horizon and variable, *LTERM*2 and *LTERM*1, related to the performance of long-term investments. The results show that the investment horizon is a significant variable at 5 % with a negative coefficient, which indicates that in our case, the socially responsible investors have a focus on short-term investments.

2.4.2 Australian Investors

We obtained our sample of investors via an online survey available for Australian investors from the RIAA.[9] Based on a literature review and discussions with experts in the field of SRI, a preliminary questionnaire was prepared. It was tested on market researchers and academic experts, incorporating comments/suggestions into the final questionnaire which consists of 37 questions, a mixture of open-ended and Likert-scaled questions.[10] The link for the online survey was displayed on the RIAA website and also published in their newsletter. There are 145 usable questionnaire responses from current SR investors.[11]

2.4.2.1 Descriptive Statistics

About one third of our sample adopt an exclusionary approach (negative criteria) to their investment strategy, 6 % inclusionary (positive criteria) and 45 % a combination of strategies. The majority of our sample are in the two extremes, 35 % invest between 0–25 and 35 % invest between 75 and 100 % of their budget. The majority of investors (61 %) indicate that they would like to exclude some specific companies from their portfolio. Only about a quarter of the sample would exclude regions (mostly communist or dictatorial regimes). Many noted a preference to support Australian companies. Fifty-three percent of respondents would exclude specific sectors, with mining being the most noted industry for exclusion. When looking for a fund the most important criteria is management reputation, closely followed by

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[9]The RIAA is an industry body for professionals working in responsible investment in Australia and New Zealand. RIAA helps individuals and organizations learn more about how they can make investment choices and take environmental, social, ethical or governance issues into account, in addition to the more conventional focus on financial objectives.

[10]A copy of the survey questions is available from the authors upon request.

[11]We acknowledge that there could be a sample selection bias. Investors who are committed to SRI are more likely to respond. Given that the focus of our study is to profile this group, selection bias is not likely to present a major problem for us.

current performance, exit fees and past performance. Annual fees and initial fees also rank, on average, as quite important. About half of the respondents look for capital growth, whereas 39 % seek a combination of growth and regular income. A slight majority seek support of a financial adviser, even though two thirds believe that they have at least a reasonable understanding of investment markets. Safety is a concern with 37 % indicating that safety is more important than higher returns. However, 35 % seek higher returns with 26 % being neutral to the trade-off between safety and returns.

The majority of participants, 66 % (81 %) have an investment horizon less than 7 (5) years. This long-term perspective is supported in answering other related questions, where 85 % indicate that they will accept a fall in their investment if long term return is good. The majority of respondents can be classified as prudent (73 %), that is, they seek a balanced portfolio to achieve their medium to long-term financial goals, while just 16 % are classified as "aggressive".

The participants also identified their level of social, ethical and/or environmental concerns. On the basis of the mean score from a rating scale of 0–4, the top ten issues of concern are: Water pollution (3.59), Climate change and greenhouse gases (3.57), Pollution (3.51), Nuclear power (3.37), Human rights (3.33), Biodiversity (3.26), Environmental management policy reporting and performance (3.25), Chemicals (3.21), Sustainable timber (3.19) and finally, Military issues (3.14). The least important issues are abortion and trade unions.

The majority of our sample of SR-Investors are young/middle aged. There are more female (74 %) than male (26 %) SR-Investor respondents. Seventy-two percent of our sample has no dependent persons, though 68 % are married/defacto. The participants are well educated with 84 % having a Bachelor degree or higher. Forty-two percent of the respondents are on a higher than average income.[12] The majority of our sample (67 %) are not religious and a slight majority (56 %) live in a big city (defined as more than 2.5 million inhabitants). Investors prefer visits to an investment advisor for initial contact when deciding to invest (41 %), but they prefer the Internet (37 %) in order to follow transactions once the initial contact has been established.

2.4.2.2 Dependent Variable

Unlike the case of Spain, the largest proportion of respondents in Australia are classified as SR-Investors. This allows us to test the predictions outlined in Table 2.2 by following several authors from the economic psychology literature, and use the proportion invested in a socially responsible way as a proxy for "moral commitment" (Lewis and Mackenzie 2000). Nilsson (2008) defines socially responsible investment behaviour as "how much the consumer invests in SRI" and

[12] Annual Average income $42,983. Source: http://stats.oecd.org

presents a model of expected influential variables on socially responsible investment behaviour.

The dependent variable is then defined in terms of categories for the percentage of the budget used to invest in socially responsible mutual funds representing "Socially Responsible Investment Behaviour". Specifically, an ordered categorical variable (0, 1, 2) is created to represent three groups:

$$DOMi = \begin{cases} 0 & \text{those that invest 0–25 \% of their budget in SR funds} \\ 1 & \text{those that invest 25–75 \% of their budget in SR funds} \\ 2 & \text{those that invest 75–100 \% of their budget in SR funds} \end{cases}$$

SRI is the dependent variable in ordered probit models designed to test the predictions outlined in Table 2.4. We consider the same three key groups of factors influencing SRI behaviour presented in the case of Spanish Investors: (1) a group of SEG variables, (2) a group of financial variables incorporating investor preferences for return, risk and types of investment, and (3) a number of socio-demographic variables.

As in the case of Spanish investors, SEG concerns are captured using 37 items on the questionnaire. To reduce the dimensionality of these potential proxies, a principal component analysis (PCA) is again conducted on the responses to these items. Eigenvalues for components 1, 2, 3, 4 and 5 were 11.03, 3.55, 2.35, 1.98 and 1.73, respectively, while the first nine components have eigenvalues >1. For reasons of parsimony we adopt a higher cut-off – selecting four components allows 50 % of the variance to be explained. We denote these as:

The majority of the SEG concerns load positively (and reasonably uniformly) onto the first component, explaining 29 % of the variance. Reference to the various loadings suggests that this variable can be interpreted as a *social conscious* factor with the highest loading on community, equal opportunity, human rights, breast milk substitutes and bribery. We label the second component as an *environmental* variable with higher loadings on issues including mining, nuclear power, pollution, sustainable timber, water pollution and intensive farming. Fur and animal testing also load onto this component. The third component covers *social/health* issues, reflected by the fact that the most relevant SEG concerns for this component are: abortion, alcohol, breast milk substitutes, intensive farming and meat sale, fur and tobacco marketing. The fourth component is deemed to reflect a *social/environmental* component with the highest loadings from gambling, greenhouse gases, nuclear power and tobacco. These results are somewhat similar to those obtained by Rosen et al. (1991) – they identify the two categories most frequently mentioned by investors as issues of concern: environment and labour relations. The rest of variables are the same as in the Spanish case study.

Table 2.4 Regression results

Regression 1: Demographics		Regression 2: SEG concerns		Regression 3: Investment style (a)		Regression 4: Investment style (b)		Regression 5: Growth–growth/income		Regression 6: Risk tolerance	
Ind V	Est. Coeff (p–value)	*Ind V*	Est. Coeff (p–value)	*Ind V*	Est. Coeff (p–value)	*Ind V*	Est. Coeff (p–value)	*Ind V*	Est. Coeff (p–value)	*Ind V*	Est. Coeff (p–value)
INC	0.11 (0.92)	*INC*	0.10 (0.45)	*INC*	0.6 (0.59)	*INC*	0.06 (0.62)	*INC*	0.00 (0.98)	*INC*	−0.02 (0.88)
AGE	0.22 (0.16)	*AGE*	0.14 (0.40)	*AGE*	0.19 (0.23)	*AGE*	0.14 (0.43)	*AGE*	0.22 (0.18)	*AGE*	0.14 (0.39)
D_{BCity}	−0.13 (0.51)	D_{BCity}	0.04 (0.86)	D_{BCity}	−0.22 (0.29)	D_{BCity}	−0.16 (0.47)	D_{BCity}	−0.08 (0.72)	D_{BCity}	−0.10 (0.66)
D_{Uni}	0.47 (0.09)	D_{Uni}	0.51 (0.10)	D_{Uni}	0.47 (0.09)	D_{Uni}	0.60 (0.04)	D_{Uni}	0.47 (0.10)	D_{Uni}	0.43 (0.12)
D_{Dep}	−0.17 (0.47)	D_{Dep}	−0.09 (0.72)	D_{Dep}	−0.1 (0.68)	D_{Dep}	−0.15 (0.56)	D_{Dep}	−0.31 (0.21)	D_{Dep}	−0.13 (0.61)
D_{Rel}	−0.29 (0.13)	D_{Rel}	−0.53 (0.01)	D_{Rel}	−0.32 (0.13)	D_{Rel}	−0.28 (0.16)	D_{Rel}	−0.25 (0.23)	D_{Rel}	−0.36 (0.07)
D_{Fem}	0.5 (0.01)	D_{Fem}	0.36 (0.12)	D_{Fem}	0.46 (0.04)	D_{Fem}	0.62 (0.00)	D_{Fem}	0.31 (0.22)	D_{Fem}	0.46 (0.06)

(continued)

Table 2.4 (continued)

Regression 1: Demographics		Regression 2: SEG concerns		Regression 3: Investment style (a)		Regression 4: Investment style (b)		Regression 5: Growth–growth/income		Regression 6: Risk tolerance	
D_{Mar}	0.26 (0.22)	D_{Mar}	0.11 (0.65)	D_{Mar}	0.3 (0.19)	S_{Mar}	0.36 (0.11)	D_{Mar}	0.23 (0.31)	D_{Mar}	0.21 (0.37)
		SEE_{PC1}	0.07 (0.02)	D_{Exl}	0.18 (0.42)	D_{SCom}	0.23 (0.31)	D_{Help}	0.20 (0.38)	*RTol*	−0.08 (0.39)
		SEE_{PC2}	0.05 (0.33)	D_{Inc}	0.51 (0.21)	D_{SReg}	0.40 (0.10)	D_{LTG}	−0.33 (0.31)	*UNDIM*	−0.05 (0.68)
		SEE_{PC3}	0.16 (0.01)			D_{SSec}	0.01 (0.97)	D_{GI}	−0.10 (0.76)	*HOR*	0.11 (0.42)
		SEE_{PC4}	0.11 (0.15)			D_{SMin}	0.01 (0.97)	$InvC_{PC1}$	−0.10 (0.05)	*LTerm1*	−0.09 (0.66)
						DOM	0.16 (0.16)	$InvC_{PC2}$	0.01 (0.92)	*LTerm2*	−0.24 (0.21)
								$InvC_{PC3}$	0.20 (0.03)		
R^2	0.04			R^2	0.04	R^2	0.07	R^2	0.04	R^2	0.06

This table presents the results from the ordered probit analysis. The dependent variable is SRI, an ordered categorical variable where $SRI_i = 0$ for those that invest 0–25 % of their budget in socially responsible funds; $SRI_i = 1$ for those that invest 25–75 % of their budget in socially responsible funds and; $SRI_i = 2$ for those that invest 75–100 % of their budget in socially responsible funds. The independent variables are specified in the first column of each pair of columns. The coefficients are reported with the p-value in parentheses

2.4.2.3 Ordered Probit Regression Results

A series of ordered probit models are estimated to assess if the level of investment in SR funds can be explained by different SEG concerns, investment strategies, decision making style, risk tolerance and demographics. Demographic variables are included in all models as a set of controls. The results are presented in Table 2.4. The quadratic hill climbing approach is adopted and Huber/White robust covariance is used.[13] The dependent variable is *SRI*, an ordered categorical variable defined earlier. We adopt a "grouping" strategy in our estimations – that is, we consider in discrete groups, independent variables around the themes discussed earlier. The independent variables are specified in the first column of each pair of columns. The coefficients are reported with the $p - value$ in parentheses.

Regression 1 provides the baseline results in which only the demographic variables are included. In this first case, only two variables produce significant coefficient estimates: the university (10 % level) and female (1 % level) dummy variables. In both instances the predicted positive relation is observed – both women and university educated respondents tend to have a higher portion of their investment budget devoted to socially responsible funds. In contrast, our sample does not support any relation between income, age, urban domicile, having dependents, religious beliefs or being married and the level of SR fund investment. These results are consistent with the literature summary presented in Sect. 2.3 with the exception that we do not find a significant age relation. The full set of demographic variables is retained as a set of controls in all remaining regressions.

The variables constructed from the PCA of the SEG concerns are combined with the demographic variables in Regression model 2. These results show that the first and third components are both significant (at the 5 % level). As discussed above, these components reflect the social conscience and social health issues of investors. Interestingly, components 2 and 4 tend to reflect environmental issues and are not significant. It seems that investors with an environmental focus are not seeking to invest a higher proportion in SR funds. The social concerns and health issues focus on community, equal opportunity, human rights, breast milk substitutes, bribery, abortion, alcohol, intensive farming and meat sale and fur/tobacco marketing. Australian SRI investors are less focused on environmental issues. Prior studies that focus on investor preferences show environmental issues are more relevant (see, for example, Nilsson 2008).

It is noted in **Regression 2** that religion has a negative and significant estimated coefficient, suggesting that investors who are religious are less likely to invest in SR funds. This finding is counter intuitive. One explanation may be the heterogeneity in the religious group. Brammer et al. (2006) explore the rela-

[13]Regression diagnostics on all specifications indicate rejection of normality. Given this situation, the choice of Huber/White covariance provides robust estimates with respect to general misspecification of the conditional distribution of the dependent variable.

tionship between religious denomination and individual attitudes to corporate social responsibility (CSR) within the context of a large sample of respondents drawn from 20 countries. Evidence found by the authors suggests that, broadly, religious individuals do not prioritise the responsibilities of the firm differently but do tend to hold broader perceptions of the social responsibilities of business than non-religious individuals. However, they find that this is true neither for all religious groups, nor for all areas of CSR. Instead of observing a clear difference between religious and non-religious individuals, the authors find a notable degree of heterogeneity within the group of religious individuals.

Regression 3 augments the demographic considerations with the broad investment style considerations – namely, whether the investor takes on an inclusionary or exclusionary strategy to their investment. First, we see that the same two demographics (university education and being female) retain their significance. However, we see that having either an inclusionary or an exclusionary style is not related to the level of SRI investment. This finding does not support our prediction. It is perhaps indicative of an evolving environment for the SR-Investors.

Traditionally, an exclusionary approach has been adopted in the formation of SR portfolios (Knoll 2002). Yet our raw questionnaire results, show that while investors are keen to exclude particular industries or countries, they are also conscious of adopting an inclusionary strategy focusing on domestic investment – akin to the well-documented "home bias" phenomenon. Furthermore, 45 % of our sample investors adopted a combination of strategies.

Regression 4. This specification incorporates more specific investment style considerations: namely, screening on country, screening on region, screening on sector, screening on mining and the level of investment devoted to domestic companies. The results show that respondents who screen on the basis of region are more likely to invest a higher proportion in SR funds (10 % level). The other possible forms of screening seem unimportant. The SR-Investors in this sample do not adopt general inclusionary/exclusionary processes. However, they are conscious of regional screens.

Regression 5 augments the demographic variable set with: the "help" dummy, growth and growth/income dummies, and the three principal components extracted from the investment characteristics variables ($InvC_{PC1}$, $InvC_{PC2}$, $InvC_{PC3}$). Of these variables, the first and third investment characteristics components are statistically significant. Specifically, the first component represents "*fund fees*" and has a negative impact on the level of investment in SR funds and a positive impact in fund financial performance. These findings are consistent with the broader literature (Rosen et al. 1991; Woodward 2000; Lewis and Mackenzie 2000; Nilsson 2008) and indicate that SR-Investors are seeking financial return as well as the non-financial benefit.

Finally, we have **Regression 6** which augments the demographic variables with risk tolerance (*RTol*), while additionally controlling for understanding of markets (*UNDIM*) and whether the investor has a long-term investment focus(*LTERM1* and *LTERM2*). Our sample fails to show significant results with regard to risk tolerance, contrary to the findings of Rosen et al. (1991) who show that SR-Investors are "somewhat risk averse". This result is consistent with a lesser focus on the risk-return relation. SR-Investors are performance and fee conscious but are not focusing on the tradeoff with risk.

Conclusions

In this chapter we have tried to shed light on the profile of the socially responsible investors. The profile of socially responsible investors has been widely studied with heterogeneous results depending on the country, the sample and the period of time of the study. In this chapter we present the results of a survey for Australian and Spanish SR investors. Both financial markets are very different with regard to the degree of popularity and penetration of socially responsible investments. Our goal is to understand preferences in SRI fund investing. The online survey covers socio-demographic characteristics, SEG characteristics, preferences in investment styles and financial characteristics including risk and return attitudes.

In our core analysis, in the case of Australia, we estimate a series of ordered probit models where the dependent variable is a categorical variable based on ranges in the percentage of their budget used to invest in socially responsible mutual funds.

To assess the SEG characteristics we ask participants to identify issues, relevant to them, from a list of 27 social, environmental and ethical concerns. Using a PCA we find four relevant categories: social conscious, including community related issues; environmental, including mining and nuclear power; social/health issues, including abortion and alcohol and; social/environmental component, including gambling and greenhouse gases. However, in our probit analysis we find Australian investors are more focused on social and social/health issues as opposed to environmental issues.

The importance of fund characteristics is assessed across a number of questions. Our PCA analysis shows that investors focus on fees, age and size of the fund and, performance. In the probit analysis, fees and performance are important to investors. In terms of the investors style there is representation from both exclusionary and inclusionary investors and some do prefer to exclude specific companies, regions or industries. However, the only significant style coefficient is the exclusion of some regions. We conclude that Australian SR investors seek to satisfy both performance and social objectives, yet the group is heterogeneous with respect to their individual investment style.

We also develop a risk tolerance variable from questionnaire responses but find this variable is not significant in SR investment. Indeed, the descriptive

(continued)

analysis of the questionnaire responses shows that the sample comprises a wide cross section of investors from very risk averse to less risk averse.

The results for Australia show that Australian SR fund investors are a heterogeneous group with varying risk preferences. They are both fee and performance conscious as well as socially responsible. Indeed, they focus on social conscious and social health issues as opposed to environmental concerns. Our study complements the vast literature using performance based analysis where researchers question the relative performance of SRI with conventional investment alternatives. While the results from these studies are mixed, many show that SRI investors are not necessarily financially penalized (see for e.g.: Statman 2000; Asmundson and Foerster 2001; Cummings 2000). Our results show that SR-Investors are indeed fee and performance conscious. We conclude that Australian SR-Investors, although they have a social conscience, are financially aware.

In the case of Spain, we find SR Spanish investors likely to be female (Beal and Goyen 1998) and, contrary to our initial predictions we find that the propensity for being socially responsible is not greater for religious investors. We also find that the older the investor the more likely to be socially responsible. This result is similar to that obtained by Beal and Goyen (1998) and Pérez-Gladish et al. (2012) for Australian investors. Surprisingly, our study reveals that Spanish SR investors tend to be lower income investors. From the reviewed studies in the literature, only Rosen et al. (1991) found the same result.

To assess the SEG characteristics we ask participants to identify issues, relevant to them, from a list of 37 social, environmental and ethical concerns. Using a PCA we find two relevant categories: environmental/ethical issues and social/health issues.

As in the case of Australia, the importance of fund characteristics is assessed across a number of questions. Our PCA on financial issues shows that investors focus mainly on fees and financial performance. In terms of the investors' style Spanish socially responsible investors do not demonstrate an exclusionary investment policy contrary to Australian investors, where there is representation from both exclusionary and inclusionary investors and some do prefer to exclude specific companies, regions or industries. Nevertheless, we conclude that Spanish SR investors like Australian SR investors seek to satisfy, performance and social objectives, yet the group is heterogeneous with respect to their individual investment style.

We also use a risk tolerance variable from questionnaire responses but we find, as happened with Australian investors, that this variable is not significant in SR investment. Indeed, as in the case of Australian investors, the descriptive analysis of the questionnaire responses shows that the sample comprises a wide cross-section of investors, from very risk averse to less risk averse.

(continued)

The obtained heterogeneous profile for Spanish investors could be explained by the scarce degree of penetration of socially responsible investment products in the Spanish market. Spanish investors are very conservative, favoring fixed income and/or traditional bank deposits over equities (EUROSIF 2012). Most of the Spanish individual investors show a lack of interest and awareness about this kind of financial products. Nevertheless, the SRI market is starting to gain popularity in Spain especially after the financial crisis. The SRI market in Spain is still dominated by a few large institutional investors, in particular large occupational pension funds. In this context, any attempt to profile SR investors could be a useful tool for promoting the success of these investment products in the market. This study confirms the results obtained by other authors about the heterogeneity of SR investors especially in those markets where SRI is less developed.

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Chapter 3
Social Performance and Financial Performance: A Controversial Relationship

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Abstract Different factors explaining divergent results on the relationship between corporate Social Performance (SP) and Financial Performance (FP) can be found in the academic literature. The main objective of this chapter is to test the impact of these factors on these divergent results. It also aims to assess the intensity of the sensitivity of this relationship to these factors considered individually or in combination. The results of our experimental research show that the estimated relationship depends on the methodological choice. More specifically, the relationship varies according to the measurement of the SP, the measurement of FP and the chosen sample. This relationship is neither stable nor necessarily linear, as many relevant academic works in the literature assume. This work concentrates on the knowledge gained from this literature and suggests lines of reflection to better understand the studied relationship in a field which is still evolving.

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3.1 Introduction

Despite its remarkable growth and the abundance of research around this concept, CSR is still an evolving concept with imprecise frontiers (De Bakker et al. 2005; McWilliams et al. 2006; Cochran 2007). A major interest of research in this field is the nature of the relationship between Social Performance (SP) and Financial Performance (FP). However and, despite the hundreds of scientific multidisciplinary papers that have examined it, the nature of this relationship remains ambiguous.

Several theories coexist to explain the impact of SP on FP, both in terms of the sign of the relationship and of its form. According to a neoclassical vision, support to social actions involves additional costs for the company as they represent a competing disadvantage (Levitt 1958; Friedman 1970). In contrast, the stakeholder theory promotes the idea that the satisfaction of all stakeholders enhances the image and reputation of the company, thus improving the FP (Freeman 1984; Donaldson and Preston 1995). Other models conclude the inexistence of a relationship between the SP and the FP. This neutrality of the relationship is explained by the compensation between the costs and benefits of CSR (McWilliams and Siegel 2001) and by the complexity of the relationship between SP and FP.

Empirically, the disparity of the findings of various studies reflects the multiplicity of coexisting paradigms. Several empirical studies support a positive impact of SP on FP (McGuire et al. 1988; Choi et al. 2010; Goukasian and Whitney 2007; Hillman and Keim 2001; McWilliams and Siegel 2000; Nelling and Webb 2009; Simpson and Kohers 2002; Waddock and Graves 1997). Other authors as Aupperle et al. (1985), Brammer et al. (2006), and Vance (1975) show a negative relationship. On the contrary, Chen and Melcalf (1980), McWilliams and Siegel (2000), and Murray et al. (2006) find no relationship. Bouquet and Deutsch (2008), Brammer and Millington (2008), and Elsayed and Paton (2009) reconcile these different findings concluding that a nonlinear relationship can be possible with a concave or convex form.

These empirical controversial results have been catalyzed by several meta-analyses which have attempted to provide a clear answer, or at least to reach consensus, about the relationship between SP and FP (Allouche et al. 2005; Margolis et al. 2007; Margolis and Walsh 2003; Orlitzky et al. 2003). Overall, the advanced conclusions refute the argument that there is a price to pay for being responsible. Most of these studies agree to recognize a small positive impact of SP on the FP. Margolis and Walsh (2003) highlight this divergence both theoretically and empirically. Indeed, in their work, of the 109 studies examining the impact of SP on the FP from 1972 to 2002, 54 conclude a positive relationship, 7 a negative relationship, 28 reporte a non-significant relationship and 20 conclude mixed results.

Several factors have been advanced to explain the disparity in results (Aupperle et al. 1985; Callan and Thomas 2009; Cochran and Wood 1984; Graves and Waddock 1999; McWilliams and Siegel 2000). In the 1980s, five main factors were identified as sources of heterogeneity between the results of previous studies.

First, the chosen period for the study can be a factor in the divergence of the relationship between studies (Barnett 2007). Given the evolving nature of social and environmental issues, we cannot expect that the relationship remains constant over time. Second, the measure of SP varies from one study to another reflecting the lack of consistency of SP measurements (Abbott and Monsen 1979; Cochran and Wood 1984). This complicates any attempt to compare the studies. In addition, measurements of SP in early studies are not suitable for the current practice of CSR. Third, the lack of consensus about FP measures seems also to contribute in explaining this discrepancy between the results of previous studies. The use of market measures (i.e. market returns, beta, Book-to-market ratio) on one side and accounting measures (i.e. ROA, return on assets, growth shares) on the other, could affect the nature of results. Fourth, several other studies suggest problems with samples (i.e. size and composition) to explain the disparity in results: lack of representation of some samples (Margolis and Walsh 2003) or the use of data which does not cross the specificities of each industry (Griffin and Mahon 1997; Russo and Fouts 1997).

The arguments suggest that methodological factors may condition the estimation of the relationship between SP and FP. To our knowledge, no study has traced the various factors of discrepancy and assessed the effect of each of these factors and their joint effects on the relationship. Far from aiming to re-examine a potential linear relationship between SP and FP, this study aims to demonstrate and assess the impact of methodological choices. The factors selected for this study are those mentioned above.

As a first step, using the same methodological tools, we try to replicate (Waddock and Graves 1997) study. This study is the most cited in the literature. Then, after obtaining results consistent with those of Waddock and Graves (1997), we tested by repeated experiments each of our assumptions, in turn releasing some constraints on the divergence factors mentioned before, namely: (1) the retaining study period, (2) the choice of the measurement of SP, (3) the choice of the measurement of FP, the sample (4) and (5), the choice of methodology.

The obtained results show that the relationship between SP and FP depends on the measurement of SP, the measurement of FP and, on the chosen sample. They also conclude that the relationship is not stable over time and that it is not necessarily linear, as suggested in the literature. Therefore, it appears impossible to build an empirical body and to consolidate the knowledge about the nature of the relationship between SP and FP.

The chapter is organized as follows: In the second section, the research hypotheses are stated. In the third section, a description of the methodology will be presented. The results will be summarized and discussed in the fourth section, and finally, the last section will present the conclusion of this work.

3.2 Research Hypothesis

The development of research hypotheses is based on the arguments found in the literature review to explain the heterogeneity of results presented in previous section. Mainly five methodological factors may be involved in the relationship.

The unique characteristics and dynamics of companies and their environments justify the non-stability of the relationship over time. As highlighted in the literature review, the concept of CSR has evolved over time. In this dynamic environment, it is therefore necessary to validate the effect of the temporal dimension of the relationship between SP and FP:

H1: The Impact of SP on FP Depends on the Period Chosen

The increase of the issues surrounding the concept of CSR has resulted in a proliferation of measures of SP. These measures vary considerably from one study to another and may explain the disparity in previous studies.

In the absence of a consensus on the measurement of SP, it is important to consider the impact of the choice of this measure on the nature of the relationship. To this end, we propose to test the following hypothesis:

H2: The Impact of SP on FP Depends on the Choice of the Measure of the SP

Measurement of the FP is also a factor that can affect the nature of the relationship between SP and FP. The indicators reflect different perspectives in the evaluation of FP and lead to different theoretical implications. This disparity can conduct to different conclusions from data of the same sample (Davidson and Worrell 1990). Some works show that the impact of SP is harder on the accounting performance compared to the stock market performance (Margolis et al. 2007; Orlitzky et al. 2003; Peloza 2009). In addition, differences in the results are observed even for studies using measures only based on accounting data. To verify if the nature of the relationship is affected by the choice of the measure of FP, we formulate the following hypothesis:

H3: The Impact of SP on FP Depends on the Choice of the Measure of FP

The literature review highlighted the fact that the samples used differ in size and in terms of their composition. To empirically test this biased sample selection (i.e. size and composition), we propose to test the following hypothesis:

H4: The Impact of SP on FP Depends on the Choice of the Sample

Several statistical methods were used to examine the impact of SP on the FP. This diversity of statistical methods makes comparison between the results inappropriate. In addition, commonly used linear methods have been criticized (Callan and Thomas 2009; Lankoski 2008; Marom 2006; Moore 2001). They are considered inadequate for reflecting the complexity of the relationship between SP and FP. On the other hand, no research adopting a nonlinear methodological approach have neither scored consensus about the nature of the relationship. It seems therefore appropriate to examine the sensitivity of the relationship between SP and FP on the choice of a restrictive linear modeling:

H5: The Impact of SP on FP Depends on the Choice of a Linear Model

This assumption will not only empirically validate the selection bias of the methodological linear approach, but also will test a possible non-linear relationship between SP and FP.

3.3 Research Method

The objective of this research is to verify if the estimate of the financial impact of SP depends on methodological factors. The various factors mentioned in the hypothesis will be analyzed in the context of some experimental research. This analytical framework will include both, the individual effect of each of these factors as well as their joint effects on the relationship. To identify methodological factors which could affect the relationship, we first study, trying to replicate it, the work by Waddock and Graves (1997), which is the most cited study in the literature on the relationship between SP and FP. We here use the same methodological criteria, the same measures of SP and FP, the same model and the same period a sample of comparable size as Waddock and Graves (1997).

Then, through controlled scenarios, we modify in turn: measures for SP and FP; the composition of the sample; the study period and the method for data analysis thus testing our hypothesis. In carrying out this series of tests, we are able to capture, not only the sensitivity of the relationship to each of these changes considered individually, but also in combination with others. This experimental exercise allows us to assess to what extent the nature of the estimated relationship between SP and FP depends on the applied methodological factors. In what follows, we present the data, the sample, the methodological approach and the model specification.

3.3.1 Description of Data and Sample

To test our hypotheses, two databases are merged: (i) Financial data from the database Compustat Research Insight and, (ii) social data from the rating agency KLD Research & Analytics Inc.

KLD evaluates the SP of a company according to 13 criteria, 7 qualitative criteria and 6 exclusion criteria: (1) employee, (2) the community, (3) products, (4) diversity, (5) governance, (6) human rights and (7), the environment. These dimensions are evaluated using several indicators are then synthesized as strengths (Strengths) and weaknesses (concerns). Exclusion criteria include six areas of activity considered as controversial: (1) alcohol, (2) tobacco, (3) game, (4) firearms, (5) military contracts and, (6) the nuclear sector. These criteria are expressed in terms of several indicators that are measured only in terms of weaknesses (concerns). KLD's rating has changed not only by adding or removing certain issues, thus taking into account the evolving nature of CSR, but also by evaluating a growing number of companies.

Despite its subjective nature, KLD provides a measure that has gained legitimacy in the academic literature (Chand and Fraser 2006; Chatterji et al. 2009; Hillman and Keim 2001; Sharfman 1996; Waddock and Graves 1997). KLD is also regarded as the most comprehensive and widely source of information used in CSR research (Carroll and Shabana 2010; Waddock and Graves 1997). In fact, the majority of the studies, including the most recent, use as a data source KLD (Baron et al. 2009; Berman et al. 1999; Bird et al. 2007; Bouquet and Deutsch 2008; Choi et al. 2010; Garcia-Castro et al. 2010; Griffin and Mahon 1997; Ioannou and Serafeim 2010; Mattingly and Berman 2006; McWilliams and Siegel 2001; Waddock and Graves 1997; Wang et al. 2008).

The sample for this study was selected from the KLD database. The intersection between the KLD database and the Compustat allows us to establish the original sample. The sample includes 647 firms for the year 1991 and reaches 2,937 companies for 2007. We have eliminated all companies that merged or were acquired during that period. This step is important because the rating year of the merger does not reflect SP of one of the companies. Finally, we removed firms with negative own funds as they may affect one of the risk measures used in our analysis, namely the debt ratio, thus biasing the interpretation of other measurements. After removing 123 observations in 1991 and 500 observations in 2007, our final sample has 524 firms in 1991 and 2,437 in 2007. From this unbalanced sample, two samples were needed to test Hypothesis 2.

The first is a balanced sample of 240 firms that takes into account all the firms in the period 1991–2007. The second sample consists of firms belonging to polluting industries. To identify the sectors called "dirty", we adopted the classification proposed by Mani and Wheeler (1998). This classification allowed us to build a sample of 109 observations in 1991 and 216 in 2007.

3.3.2 Methodological Approach

The methodological approach adopted in this study is based on six steps.

First step. As a first step, we replicated the study by Waddock and Graves (1997), using the same measures of SP and FP, the same methodology, the same control variables and the same study period. Our aim was first, to check the "replicability" of the results of the study chosen as a reference. The results of this step represent our initial results which will serve as a reference for our hypothesis testing.

Second step. To test Hypothesis 1, we extend the study period in Waddock and Graves (1997) from 1992 to 2007. Thus, by controlling the composition of the sample and the regression model used for the measurement of SP and FP, we check the stability of the initial results over time.

Third step. We here test Hypothesis 2 by releasing the constraint on the measurement of SP. In this analysis, we opt for a public multidimensional measure increasingly used in research (Becchetti et al. 2007; Callan and Thomas 2009; Choi and Wang 2009; McWilliams et al. 2006; Wang and Choi 2013), namely the equally weighted index KLD. This index takes the same conceptual definition as the measure used by Waddock and Graves (1997). However, it assigns equal weights to the different dimensions of KLD.

Fourth step. In this step the same experimental protocol was applied to highlight the impact on the relationship of the choice of FP measure, which is Hypothesis 3. Two measurement categories of FP were used: accounting measures (i.e. ROA, ROE and ROS) and a market measure (i.e. total return). The comparison of results obtained with each of these measures, *ceteris paribus*, highlights the impact of the choice of the measure of the FP on the relationship between SP and FP.

Fifth step. In a fifth step, releasing the constraint on the composition of the sample, we check whether the results of Waddock and Graves (1997) can be generalized to other contexts. Two samples are used to test the Hypothesis 4. The first is a sample composed of the same 240 companies, for a period from 1991 to 2007. This balanced sample is comparable to Waddock and Graves (1997) sample at the sector composition. However, it differs in size. The second is a sample of firms belonging to a specific industry. This sample consists only of firms belonging to polluting industries. Analysis made on these samples allows us to test the sensitivity of the relationship to the choice of the sample regarding both, the size and the composition.

Sixth step. Finally, in order to test Hypothesis 5 on the sensitivity of the relationship to the choice of the model, we compared the results of the linear model proposed by Waddock and Graves (1997) with an alternative linear model, controlling for other methodological components. The alternative model captures the relationship at the extreme values of SP. The contribution of the results obtained in this step is twofold. Not only is it possible to test the hypothesis 5, but it is also possible to capture the behavior of the relationship at different levels of SP, which leads indirectly to validate the non-linearity of the relationship.

3.3.3 Measures

3.3.3.1 Dependent Variables

Like Waddock and Graves (1997), we use three measures of FP, namely return on assets (ROA), return on equity (ROE) and return on sales (ROS). These measures are often used in the literature on the relationship between SP and FP (Kapoor and Sandhu 2010; Mishra and Suar 2010; Nelling and Webb 2009; Preston and Obannon 1997; Tsoutsoura 2004). Other works using market information to assess the FP are: Brammer et al. (2006), Graves and Waddock (1999), McGuire et al. (1988), Seifert et al. (2004), and Seifert et al. (2003). Thus, for comparison purposes, we have completed the series of accounting indicators used by Waddock and Graves (1997) by considering a market measure, the annual yield of the security on the financial market.

3.3.3.2 Independent Variables

Two measures of SP, derived from the KLD database, are considered. The first is a replica of the weighted measure used by Waddock and Graves (1997). The latter consists of eight dimensions whose weights are as follows: (0.168) for the relationship with employees (0.154) for the product (0.148) for the relationship with communities (0.142) for the environment (0.136) for the treatment of women and minorities (0.089) for the nuclear power and military contracts and (0.076) for investment in South Africa. SP weighted average for each firm is calculated as follows:

$$SP_i = \frac{1}{8}\sum_{i=1}^{8}(0.168\,Emp_i + 0.154\,Pro_i + 0.148\,Com_i + 0.142\,Envt_i + 0.136\,Div_i + 0.076\,Hum_i + 0.089\,Nuc_i + 0.086\,Mil_i) \tag{3.1}$$

The second measure of SP is an alternative measure corresponding to an average of 13 equally weighted and aggregated dimensions of KLD. In fact, the score for each dimension is obtained by subtracting the sum of the forces (Strengths) to the sum of weaknesses (Concerns). The SP equally weighted average for each firm is calculated as follows:

$$SP_i = \frac{1}{13}\sum_{i=1}^{13}(Com_i + Div_i + Gov_i + Hum_i + Emp_i + Envt_i + Pro_i + Alc_i + Arm_i + Jeu_i + Mil_i + Nuc_i + Tab_i) \tag{3.2}$$

With Com: community, Div: diversity, Gov: Governance, Hum: human right, Emp: employee, Envt: environment, Pro: product, Alc: alcohol, Arm: Weapon, Game: games, Mil: military, Nuc: nuclear and Tab: tobacco.

3.3.3.3 Control Variables

We included in this study the control variables considered by Waddock and Graves (1997). The authors examined the impact of SP on FP controlling for firm size (T), the level of risk (R), as well as for the industry (I). Size, often considered as a factor affecting the relationship between SP and FP (Russo and Fouts 1997; Ullmann 1985; Wu 2006), is measured by the total assets. The risk, in turn, is measured by the leverage, i.e. the ratio of total debt to equity. Some studies have also shown that the level of financial leverage affects investment policy in social practices (Choi and Wang 2009; Jensen 1986; Kapoor and Sandhu 2010; Tsoutsoura 2004; Zyglidopoulos 1999). To avoid differences, due to the diversity of industries, in the FP in our sample, binary variables are introduced to control the effect of the industry. These variables are obtained from the description of the primary SIC code (4 indices) of the firm and allow us to distinguish 13 industries.

3.3.4 Model Specification

$$FP_t = \alpha_0 + \alpha_1 \cdot PS_{t-1} + \alpha_2 \cdot T_{t-1} + \alpha_3 \cdot R_{t-1} + \alpha_4 \cdot I_{t-1} + \varepsilon_t \quad (3.3)$$

The use of a cross-sectional regression model (3.3) allows measurement of the impact of SP on FP for year 1991. The same regression is estimated for each year in the period 1992–2007 to test the stability of the relationship over time. This model also allows us to evaluate a possible change in the behavior of the relationship related to changes on SP (i.e. equally weighted SP) or FP measurement (i.e. market measure). Then, the estimation of Waddock and Grave's model using other samples has led us to recognize the ability of the model to provide results generalizable to other populations.

To test the Hypothesis 5 concerning the impact of the choice of the methodology on the relationship, we propose the following alternative linear model:

$$\begin{aligned} FP_t = \alpha_0 + \alpha_{11} \Pi_{PS \leq q_1} SP_{t-1} + \alpha_{12} \Pi_{PS \geq q_2} SP_{t-1} + \alpha_2 \cdot T_{t-1} \\ + \alpha_3 \cdot R_{t-1} + \alpha_4 \cdot I_{t-1} + \varepsilon_t \end{aligned} \quad (3.4)$$

where, Pi is the dummy variable; q_1 quartile 25 %; q_2 75 % quartile.

Specification (3.4) allows us to highlight the behavior of the relationship with respect to extreme values. The estimation of these coefficients allows us to capture a non-linear relationship. Indeed, if these coefficients are significantly different, then we can say that the relationship changes for extreme levels of SP. This would imply that the impact of SP on FP is not monotonic. Otherwise, a linear relationship between SP and the FP is supported, as suggested by Waddock and Graves (1997). The comparison of the results of the estimation of this model to those of Waddock and Graves (1997) also allows us to see how the results are influenced by the used method. Also, the estimation of this model on the sub-periods from 1991 to 2007 allows us to examine the sensitivity of the relationship to the chosen period of study.

3.4 Results

Tables 3.1 and 3.2 displays the descriptive statistics and correlation matrix for the main variables used in our analysis for the year 1991. On average, firms show a positive score for both measures of SP (i.e. $SPpond = 0.053$ and $SPeq\_pond = 0.005$). Three FP measures show that on average, companies that constitute our sample are profitable (i.e. rend_annual = 0.011, 0.052 = ROA and ROE = 0.096) with a medium risk level of 22.7 %. FP is assessed by recording ROE greatest variation compared to the other two measures (i.e. 28.7 %).

The results of the correlation matrix show that the two SP measures used are positively correlated with FP accounting measures (i.e. *ROA* and *ROE*) and uncorrelated with the market measure (i.e. annual return). For the control variables, the sign of the correlation depends on the extent of FP. The control variable risk, as measured by financial leverage is negatively correlated with *ROA* and *ROE* accounting measures and not correlated with FP (measured by the annual return). For the control variable size, a negative correlation was obtained with *ROA*, whereas no correlation with *ROE* variables and annual return is recorded. In sum, the results obtained from the correlation matrix are comparable to those of regarding the sign of the coefficients.

Table 3.1 Descriptive statistics for year 1991

Variables	N	Mean	Standard deviation	Minimum	Maximum
SPpond	524	0.053	0.285	0.053	0.285
SPeq_pond	524	0.005	0.172	0.005	0.172
SPf	524	−0.079	0.171	−0.079	0.171
SPe	524	0.100	0.187	0.100	0.187
Rend_annual	524	0.011	0.025	0.011	0.025
ROA	524	0.052	0.069	0.052	0.069
ROE	524	0.096	0.287	0.096	0.287
Lev	524	0.227	0.155	0.227	0.155
Size	524	9,839.136	23,896.28	9,839.136	23,896.28

Note: A sample of 524 companies for the year 1991 has been used. *SPpond* is a replica of the SP measure used by Waddock and Graves (1997). *SPeq_pond* is the SP measure calculated as an equal-weighted average aggregating the 13 criteria considered by KLD. *SPf* is the score of the weighted SP belonging to the 25 % quantile. *SPe* is the score of the weighted SP belonging to the 75 % quantile. *Rend_annual* is the annual return of the security on the financial market. ROA is the rate of return on assets. *ROE* is return on equity. *Lev* is leverage measured by the ratio of debt to equity. Size is measured by total assets

Table 3.2 Correlation matrix for year 1991

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) *SPpond*	1								
(2) *SPeq-pond*	0.966***	1							
(3) *SPf*	0.791***	0.791***	1						
(4) *SPe*	0.754***	0.696***	0.246***	1					
(5) *ROA*	0.095**	0.110**	0.125***	0.008	1				
(6) *ROE*	0.092**	0.100**	0.106**	0.041	0.721***	1			
(7) *Rend_annual*	−0.002	−0.001	0.018	−0.011	0.006	0.016	1		
(8) *Lev*	−0.091**	−0.106**	−0.132***	−0.009	−0.336***	−0.090**	0.006	1	
(9) *Size*	−0.019	−0.071	−0.165***	0.137***	−0.197***	−0.048	0.036	0.212***	1

*** Significant at 0.1 % ($p \leq 0.001$); ** significant at 1 % ($p \leq 0.01$); * significant at 5 % ($p \leq 0.05$)

The results from the correlation matrix also show a positive correlation between accounting measures of FP and low levels of SP (0.125 or 0.106 with ROA and with ROE), while the correlation is not significant for high levels of SP. This implies that the degree of correlation depends on the level of SP. However, when the annual yield is used as a measure of FP, the correlation remains insignificant, regardless of the level of SP.

The results of the regression analysis obtained from Model (3.1) are presented in Table 3.1. The results for 1991 show that the impact of SP on the FP, as measured by *ROA* (*ROE*) is significantly positive (not significant). These results, which are similar both in terms of the sign on the significance of the coefficient of SP (0.015 and 0.060 with *ROA* and *ROE*, respectively), confirm the empirical results of that study. Thus, when using the same measures of SP and FP, the same study period, the same linear methodology and a sample it is possible to reproduce Waddock and Graves (1997) results regarding the impact of SP on FP.

From this controlled scenario and to test our hypotheses we will modify in turn various methodological factors in order to assess their impact on the relationship between SP and FP.

3.4.1 The Impact of SP on FP Depends on the Period of Study

By releasing stress on the period of study, our results do not support the findings of Waddock and Graves (1997) (Table 3.3). Thus, by comparing the impact of SP on the FP with different periods from 1992 to 2007, we find that this relationship varies over time. For the periods from 1991 to 1993, the impact of SP on FP is positive, corroborating the results obtained by other authors for the same periods (Griffin and Mahon 1997; Ruf et al. 2001; Russo and Fouts 1997; Turban and Greening 1997). Subsequently, the relationship is not significant for the periods from 1994 to 1997. In more recent periods, from 2001 to 2007 (except for 2006), the relationship is positive and significant. This result is confirmed in the works of Callan and Thomas (2009) and Siegel and Vitaliano (2007), which validate a positive financial impact

Table 3.3 SP coefficient for the cross-sectional regression model (3.1) (Unbalanced sample)

Dependent variables		Accounting measure: ROA		Accounting measure: ROE		Market measure: *Rend_annual*	
Waddock and Graves (1997)		0.024***		0.081			
Years	*N*	*SPpond*	*SPeq-pond*	*SPpond*	*SPeq-pond*	*SPpond*	*SPeq-pond*
1991	524	0.015*	0.022+	0.060	0.081	−0.001	−0.002
1992	525	0.016+	0.022	0.021	0.018	−0.025	−0.033
1993	508	0.015*	0.020	0.089*	0.138*	−0.000	−0.003
1994	502	0.011	0.009	0.026	0.015	0.005*	0.006
1995	524	0.012	−0.004	−0.260	−0.321	0.005*	0.007
1996	528	−0.002	−0.005	−0.017	0.000	0.004	0.008+
1997	538	0.009	0.013	0.063	0.075	0.008*	0.010+
1998	539	0.017**	0.020+	0.099*	0.111	0.145**	0.175+
1999	557	0.012+	0.016	0.223	0.376	0.001	0.001
2000	582	0.003	0.008	0.022	0.042	−0.000	−0.007
2001	1,026	0.055**	0.065*	0.120	0.052	0.005+	0.008
2002	1,048	0.026***	0.046**	0.088*	0.155*	−0.002	−0.006
2003	2,755	0.044***	0.034*	0.048	−0.106	0.024	0.056
2004	2,814	0.039***	0.011	0.065	−0.094	0.000	−0.004
2005	2,773	0.025***	0.005	−0.103	−0.177	−0.001	−0.003
2006	2,379	0.007	−0.017	−0.420	−0.829	−0.006**	−0.013**
2007	2,437	0.030*	0.048*	−0.865	−0.758	0.001	0.003

Note: This table summarizes the results of the estimation by OLS regression models in cross-section for the period from 1991 to 2007

***Significant at 0.1 % ($p \leq 0.001$); **significant at 1 % ($p \leq 0.01$); *significant at 5 % ($p \leq 0.05$); +significant at 10 % ($p \leq 0.1$ %); N: number of observations

of SP on the respective periods of 2002 and 2004. According to Goll and Rasheed (2004), developments in the field of CSR explain the positive results of recent works, compared to previous studies.

Thus, we cannot reject the Hypothesis 1 that supports the impact of the choice of the period of study on the relationship between SP and the FP. This is consistent with the arguments presented by Barnett (2007), which excludes stability of the financial impact of SP given the unique character and dynamics of the firm and its environment. According to Hoepner et al. (2010), a homogeneous financial impact of CSR through time is not possible. Time affects many variables that moderate the relationship between SP and FP. For example, the severity of problems due to the accumulation of negative externalities of the company, the scope and speed of information dissemination and the social environment or the fast dissemination of information about the irresponsible actions and scandals of the firm are elements that evolve and thus, affect differently the relationship between SP and the FP over time.

3.4.2 The Impact of SP on FP Depends on the Extent of SP

Table 3.3 summarizes the main results regarding Hypothesis 2. These results show that we cannot reject this hypothesis and that the relationship depends on the choice of the measure of SP. Controlling for the extent of the FP, sample and methodology, we note that the choice of measure affects the relationship. For example, when considering the relative importance of each issue using a weighted measure of SP, the impact of SP on the FP is positive and significant at 0.1 % for 2004 and 2005, compared with an equally weighted measure where the relationship becomes statistically zero.

Several previous studies illustrate the variation of the relationship as a function of the measure of SP. For the year 1992, our results with a weighted measure of SP, support a positive relationship, unlike the results of Cordeiro and Sarkis (1997) who obtain a negative relationship between SP, measured by TRI, and FP. For 1994, our results for the weighted measure of SP support a lack of relationship. In the same year, Stanwick and Stanwick (1998) validate, in turn, a positive financial impact of SP, as measured by the disclosure of environmental information. For 1998, our results support a relationship rather positive, while Seifert et al. (2004) show no relationship between SP, measured by philanthropy, and FP for the same year.

The discrepancies between the results even exist between studies using multidimensional measures of SP. For 2002, our results show a positive financial impact of SP while Brammer and Pavelin (2006) obtained a negative relationship between an aggregate measure of SP and FP. Like the results of Choi et al. (2010), our results show disparity, even with SP measurements derived from the same database. For example, for several years (1992–1993–1999–2004 and 2005), the financial impact of SP based on a weighted score is positive whereas the effect becomes insignificant using equally weighted aggregate measure. This means that when an issue becomes more salient and therefore, with greater financial impact (Barnett and Salomon 2006; Bird et al. 2007), using an equally weighted measure does not fully capture the impact on FP.

3.4.3 The Impact of SP on FP Depends on the Extent of FP

To test Hypothesis 3, we released the constraint on the measurement of FP while controlling for other methodological factors. According to the results summarized in Table 3.3, the impact of SP depends on the choice of FP measurement. Not only the results for the FP measured by accounting data differ from those based on market data but also results based on different accounting measures. The results from both accounting measures and market measures cannot reject Hypothesis 3.

For the year 1991, contrary to Waddock and Graves (1997) results, the impact of SP on FP measured by the market return is not significant. By extending the analysis to other periods, our results confirm the lack of convergence in the results from accounting measures, compared with those based on market data, and over several years. In 2006, for example, the financial impact of SP is not significant for the two accounting measures (i.e. *ROA* and *ROE*), whereas for the market measure the relationship becomes significantly negative at 1 % level. This is consistent with the results obtained by Garcia-Castro et al. (2008) who show a neutral financial impact on SP using *ROA*, *ROE* and Tobin's Q, but also a negative effect when FP is measured by the Market Value Added (MVA).

This variability in results also appears when using different accounting measures. The results show that the financial impact of SP depends on whether FP is measured by *ROA* or *ROE*. For the years 2003, 2004 and 2005, there is a financial positive impact significant at 0.1 % when using *ROA* which becomes insignificant when using *ROE*. These findings are consistent with those of Callan and Thomas (2009). These authors also found that in 2004, the relationship between SP and FP is significantly positive at the 5 % level only for the *ROA* and *ROE*. The use of *ROE* results in a rather insignificant financial impact of SP.

3.4.4 The Impact of SP on FP Depends on the Selected Sample

The results of tests of the Hypothesis 4 on the impact of the choice or composition of the sample on the relationship between SP and FP are presented in Table 3.4. We constructed three samples: an unbalanced sample, a balanced sample and a sample that includes only companies from polluting industries. We note that the results from these samples, when compared to those obtained by Waddock and Graves (1997) during 1991, remain substantially the same. However, when extending the analysis to other periods, the results vary depending on the selected sample. The findings from the balanced sample differ from those obtained with unbalanced data. For example, for the years 1996, 1997 and 2001, the impact of SP on FP is neutral for the unbalanced sample, while it is positive for the balanced sample.

In order to check if the composition of the sample is a factor that affects the relationship between SP and FP, we used a homogeneous sample composed of companies from the same industry. In this case, the results show different conclusions. Indeed, over the 17 years only for 5 years we obtain a positive and significant relationship between SP and FP, compared to the 11 years where this relationship was found using an unbalanced sample. Thus, with the obtained results from different samples we cannot reject Hypothesis 4. Hoepner et al. (2010) also show that the relationship between SP and FP can be similar across different industries. Matten and Moon (2008) and Rowley and Berman (2000) explain that the industrial characteristics are factors that moderate the relationship between SP and FP.

Thus, the characteristics of the selected sample can affect the impact of SP on the FP and therefore they can be considered as an explanation for the divergent results found in the academic literature.

Table 3.4 SP coefficient in the cross-sectional regression model (3.1) for different samples

Dependent variables	Unbalanced sample		Balanced sample (N = 240)		Polluting industries sample	
Year	*ROA*	*ROE*	*ROA*	*ROE*	*ROA*	*ROE*
1991	0.015*	0.060	0.025**	0.140+	0.038+	0.253
1992	0.016+	0.021	0.006	−0.008	0.029	0.064
1993	0.015*	0.089*	0.014+	0.096*	0.038***	0.181
1994	0.011	0.026	0.023**	0.159*	0.017	0.031
1995	0.012	−0.260	0.011	0.047	0.014	0.097
1996	−0.002	−0.017	0.018+	0.094	0.006	0.226
1997	0.009	0.063	0.018*	0.125	0.023	0.105
1998	0.017**	0.099*	0.021*	0.101**	0.030**	0.071*
1999	0.012+	0.223	0.018*	0.355	−0.017	0.043
2000	0.003	0.022	0.000	0.036	0.007	0.151
2001	0.055**	0.120	0.000	0.043	0.062+	0.534
2002	0.026***	0.088*	0.015+	0.022	0.048*	0.194+
2003	0.044***	0.048	0.019**	0.076**	0.022	0.072
2004	0.039***	0.065	0.024**	0.056	0.003	−0.050
2005	0.025***	−0.103	0.014+	0.084*	0.003	0.039
2006	0.007	−0.420	0.004	0.409	−0.039	0.365
2007	0.030*	−0.865	0.009	0.193*	0.042	0.173

Note: This table summarizes the results of the estimation by OLS regression models in cross-section for the period from 1991 to 2007 on three samples: (1) unbalanced sample, (2) balanced sample of 240 companies and (3) sample consisting of firms belonging to polluting industries0
***Significant at 0.1 % ($p \leq 0.001$); **significant at 1 % ($p \leq 0.01$); *significant at 5 % ($p \leq 0.05$); +significant at 10 % ($p \leq 0.1$ %)0; N: number of observations

3.4.5 The Impact of SP on FP Depends on the Model Used

To test the hypothesis 5, two linear models were estimated and compared to assess the impact of a change in the choice of the model on the relationship. The first model is that of Waddock and Graves (1997) which assumes a monotonic relationship between SP and FP (Model 3.1). The linear model 2 captures the impact of SP on the FP for extreme levels of SP (i.e. first quartile 25 % and third quartile 75 %). This formulation also allows checking if the financial impact is the same regardless of the level of SP. The results of Model (3.1) (Table 3.4) and Model (3.2) (Table 3.5) confirm that the choice of method affects the type of relationship between SP and FP. Replication of the results from Waddock and Graves (1997) was not conclusive with the modification of the methodological approach (all other factors being equal). The coefficients of the model according to SP show that the impact of SP on the FP is only significant at the firm level for extremely low SP levels, unlike Waddock and Graves (1997) that validate a positive financial impact, whatever the level of SP.

In addition, unlike the results of Waddock and Graves (1997), this result indicates that the relationship is not monotonically positive. Indeed, between 2001 and 2007,

Table 3.5 SP coefficient in the cross-sectional regression model (3.2) (unbalanced sample)

Dependent variables		ROA		ROE	
Years	*N*	*SPf*	*SPe*	*SPf*	*SPe*
1991	524	0.026*	0.000	0.109	0.015
1992	525	0.032*	−0.001	0.035	−0.005
1993	508	0.034**	−0.002	0.038	0.104+
1994	502	0.023	0.001	0.018	0.059
1995	524	0.015	0.005	−0.620	−0.044
1996	528	0.018	−0.012	0.159	−0.105
1997	538	0.013	0.009	0.093	0.031
1998	539	0.031*	0.013	−0.102	0.164*
1999	557	0.028*	0.001	0.247*	0.192
2000	582	0.015	−0.002	0.089	−0.008
2001	1,026	0.023	0.078*	−0.449	0.459*
2002	1,048	0.036**	0.021+	−0.080	0.190*
2003	2,755	0.001	0.096***	−0.212	0.330***
2004	2,814	−0.012	0.092***	−0.135	0.285**
2005	2,773	−0.032*	0.076***	−0.478	0.229*
2006	2,379	−0.050**	0.054***	−0.692+	−0.215
2007	2,437	−0.047*	0.106***	−0.673	−0.662

Note: This table summarizes the results of the estimation by OLS regression models in cross-section for the period from 1991 to 2007. Control variables for industry are identified according to the description of the primary SIC code of the firm00
***Significant at 0.1 % ($p \leq 0.001$); **significant at 1 % ($p \leq 0.01$); *significant at 5 % ($p \leq 0.05$); +significant at 10 % ($p \leq 0.1$ %) 00; N: number of observations 0

it is clear that the relationship is sensitive to high levels of SP where the impact of SP on the FP is positive and significant. From 2005, the results show that extremely low levels of SP negatively affect the FP. Thus, comparing our results with those of Waddock and Graves (1997), we cannot reject the hypothesis 5.

The results from Model (3.2) allow us to demonstrate that the relationship is not monotonically increasing as assumed by Waddock and Graves (1997). Our results support a relationship that depends on the level of SP, reflecting a non-linear impact of SP on the FP. An examination of the relationship over the entire study period shows that the behavior of the relationship changes over time. However, the impact of SP on the FP appears to have stabilized from 2001, supporting a positive relationship for firms with high levels of SP. Over the period from 2005 to 2007, the results show an asymmetry in the relationship which results in a significant negative impact for low levels of SP and a significant positive impact on high levels.

In sum, the results obtained by Waddock and Graves (1997) are specific to the study period, selected measures of SP and FP, the used sample and the methodology adopted. Therefore, the results cannot be generalized. This shows that the nature of the relationship between SP and FP is contingent on these factors. It is therefore difficult to draw definitive conclusions on the subject.

Conclusions

The debate around the concept of CSR continues to grow, both in practical and academic terms. Literature about CSR shows the absence of a consensus definition which has resulted in a lack of uniformity in measures of SP. Moreover, thanks to greater availability and regularity of publication and dissemination of data, measurement of SP has contributed to a broader increased assessment that explicitly takes into account several aspects of CSR.

The question of the financial impact of SP is still today one of the most discussed topics in the literature on CSR. The relationship between SP and FP has been extensively studied for several decades without reaching a consensus as to its nature. Studies examining different categories of firms at different times, using several measures of SP and FP and opting for various methodological approaches do not provide a clear answer to the question. Several meta-analyses in the academic literature have attempted to classify, aggregate and analyze the results of a large number of works. Although their findings tend to support a positive relationship, Margolis and Walsh (2003) have cautioned against hasty conclusions.

The aim of this research was to analyze the contradictions that characterize the literature on the subject. This research tries to make a contribution to the debate by exploring the question of the relationship between SP and the FP from another angle. Our goal was not to formalize the current state of knowledge, but rather to illustrate or demonstrate the real impact of the choice of different components of any research methodology on the empirical estimation of the relationship between SP and FP.

While the aim of this research is to be explanatory, it remains exploratory. The choice of methodology is oriented towards an experimental analysis which is designed to replicate the study by Waddock and Graves (1997). From this controlled scenario, we have tested by repeated experiments each of our assumptions in turn showing some determinant factors on differences.

In general, this research has allowed us to conclude that the impact of SP on FP is significantly influenced by each of the methodological factors identified in the literature review.

Given the exploratory nature of this work, the results can be considered as a starting point for reflection and research. The essential question to be raised is the need for a reliable measurement of SP based on a standardized definition. The second question is closely related to the first and concerns the temporal dimension that affects the relationship. The evolution of the concept of CSR has been marked by events that affect the society and environment – such as the Kyoto Protocol in 1997 and the launch of the PRI in 2006 – or by events that affect the economic and financial context- such as the stock market crisis in 2000 or the housing crisis in 2007. These key dates should

(continued)

be considered in the analysis and interpretation of the relationship between SP and the FP. In this context, it is clear that we should not expect to have a stable, unambiguous and systematic relationship between SP and FP.

The results of this research also raise questions regarding the adequacy and effectiveness of the methodological approaches adopted in previous studies. Our results suggest that we cannot continue to confine the analysis of the relationship to linear models. The relationship seems to depend on the level of SP and it is not necessarily linear. The lack of consensus in this sense may reflect the limits and the inability of the methods used until now to consider the complexity of the relationship and its evolving nature. The relationship depends on several contingency factors related to the company and its environment which are dynamic. Extrapolation of the results to different companies, in different contexts, different issues or different periods is problematic (Lankoski 2008).

In conclusion, obtaining a universal explanation of the relationship seems to be a difficult task. In order to deliver concrete results that can be used in future research, it is necessary to improve the measurement of SP and the techniques for statistical analysis of the data as well as focus on the knowledge and on the identification of contingency factors affecting the relationship.

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Chapter 4
Measurement of Assets' Social Responsibility Degree

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Abstract As we have seen in Chap. 3, one of the critical issues in SRI analysis is how to measure social responsibility levels of financial assets. Frequently, there is available disaggregated information on SRI strengths and concerns of assets from each socially responsible criterion. This information is usually provided by independent institutions like rating agencies. Most of the times the available data are presented in a disaggregated way and the individual investor has not got an aggregated indicator of the Social Responsibility Degree (SRD) of each asset. This indicator can be constructed in a subjective or objective way depending on the needs of each investor. In this chapter, we review the current practice and the most widely used methods in the academic literature mainly based on subjective approaches. In these approaches the aggregation weights depend on opinions and preferences of particular analysts, fund managers or investors.

4.1 Introduction

SRI is a growing and important investment field and therefore there is an increasing body of literature which pays attention to it. Nevertheless, most of the academic research is focused on the discussion of the financial performance of social

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responsible funds, while few indicators have been developed for mutual funds' socially responsible performance measurement. Therefore, it is necessary to construct a suitable social responsible level indicator which could assist investors in the evaluation of financial assets, especially mutual funds, from a social responsible point of view. It is necessary for this indicator to take into account the multiple dimensions of social responsibility, related not only to the companies' behavior but also to the mutual funds' investment strategies (screening approach, engagement policy, community involvement, proxy voting policy. . .).

Investors seeking to invest only in Social and Environmental Responsible (SER) firms have grown to become an unavoidable fact in capital markets. Indeed, the last financial crisis and the succession of financial scandals have catalyzed and reinforced the SER investors' movement.

In order to assist socially responsible investors in identifying and selecting socially responsible investments, several signals and measurements have reached financial markets: certifications, codes of conduct and social notations by agencies. Because certifications are specific to the industry where companies operate, and the codes of conduct are often idiosyncratic to the firms, the social rating agencies try to standardize social and environmental information conveyed in connection with the companies. In what follows we will review some of the current evaluation practices applied by both, practitioners and academic researchers.

4.2 The Role and Practice of Social Rating Agencies

The process of determining if the enterprise meets the principles of Socially Responsible Investing (SRI) has been widely discussed. According to de la Cuesta González and Valor Martínez (2003) this task is called "Social Auditing Process" and includes two stages:

(a) *First Stage: Normalization*. It consists in establishing and disseminating the SRI principles.
(b) *Second Stage: Social screening or social rating*. At this point, an independent agency certifies that the enterprise meets the requirements established in the earlier stage.

Nowadays, normalization is more widely developed than social screening or social rating. In fact, when discussing this point, more than 200 SRI principles arise. However, not all of them are equally well-known. In the last few years, there is a growing recognition that defining a worldwide ISO standard about SRI principles seems necessary. The main SRI principles are displayed in Table 4.1. These are classified as sector principles and overall principles. Most of the sector principles are concentrated on labour relations (e.g., Investors in people). Other sector principles focus on human rights (Amnesty International Principles for Companies) or focus on environmental policies (ISO 14000).

Table 4.1 Main SRI principles

Sector principles	• Amnesty international human rights principles for companies • Clean clothes campaign code of labor practices • FLA charter management • IFCTU basic code of labour practice • ISO 14000 • Investors in people • SA 8000
Overall principles	• United Nations global compact • Accountability 1000 • Caux roundtable principles • CERES principles • Ethical trading initiative base code • Fortune's corporate reputation index • Global reporting initiative (GRI) • Global Sullivan principles • Os for multinational enterprises

Source: de la Cuesta González and Valor Martínez (2003)

About the overall principles, these focus on environmental policies (e.g., GRI Initiative) or human rights (e.g., Global Sullivan Principles) to cite but a few examples. On the other hand, social screening or social rating is usually carried out by independent agencies. These agencies elaborate databases containing information about the SRI character of each enterprise. They also elaborate ethical indexes. World's leading independent agencies conducting social screening or social rating are shown in Table 4.2.

Table 4.3 displays the mostly applied social screens by rating agencies (Perez-Gladish and M'Zali 2010). The main SRI databases are associated with SIRI Group (www.siri.org). Concerning ethical indexes, they are stock market indexes submitted to an ethical screening test. Examples of these ethical indexes are:

(i) Domini Social Index (now known as MSCI KLD 400 Social Index, http://www.msci.com/)
(ii) Dow Jones Sustainability Index (Dow Jones Group and Sam Group, www.sustainability-index.com)
(iii) FTSE4Good (FTSE and EIRIS, www.ftse4good.com)
(iv) Aspi Eurozone Indexes
(v) Citizens Index
(vi) The most recent index is KLD-Nasdaq Social Index, jointly developed by KLD Research & Analytics Inc. and Nasdaq Stock Market.

Table 4.2 Main social investment forums and independent rating agencies

Agency	Country
Ethical Investment Services http://www.ethicalinvestments.com.au	Australia
Ethinvest http://www.ethinvest.com.au/	Australia
Corporate Monitor http://www.corporatemonitor.com.au/	Australia
RIAA (Responsible Investment Association Australasia) http://responsibleinvestment.org/	Australia
BELSIF (Belgian Sustainable and Socially Responsible Investment Forum) http://www.belsif.be/	Belgium
VIGEO http://www.vigeo.com/	France
ASRIA (Association for Sustainable and Responsible Investment in Asia) http://www.asria.org/	Hong Kong
Forum per la Finanza Sostenible http://www.finanzasostenibile.it/	Italy
Good Bankers http://www.goodbankers.co.jp/	Japon
Storebrand http://www.storebrand.no/	Norway
DSR (Dutch Sustainability Research) http://dsrresearch.nl/	Netherlands
GES Investment Services (Global Ethical Standard) http://ges-invest.com/	Sweden
SWESIF http://www.swesif.org/	Sweden
INrate http://www.inrate.ch	Switzerland
Sam Research http://www.sam-group.com/	Switzerland
FTSE http://www.ftse.com/	UK
Core ratings http://www.coreratings.com	UK
EIA (The Ethical Investment Association) http://www.ethicalinvestment.org.uk/	UK
EIRIS (Ethical investment research services) http://www.eiris.org/	UK
UKSIF http://www.uksif.org/	UK
PRI (Principles for Responsible Investment) http://www.unpri.org/	US

(continued)

Table 4.2 (continued)

Agency	Country
MSCI ESG STATS (former KLD, Kinder, Lydenberg, Domini & Co., Research & Analytics, Inc.) http://www.msci.com/	US
NI (Natural Investment) http://www.naturalinvesting.com/	US
Calvert Group http://www.calvertgroup.com/	US
Innovest http://www.innovestgroup.com	US
USSIF (Social Investment Forum) http://www.socialinvest.org/	US

Source: Own elaboration

Table 4.3 Principal social, environmental and ethical issues considered by rating agencies in Europe and U.S.

Social, environmental and ethical issues	SIF	EIRIS	Corporate monitor	KLD	VIGEO
Abortion/contraceptives					○
Air and water pollution			○	○	
Alcohol	○	○	○	○	○
Animal testing/animal welfare	○	○		○	○
Biotechnology/genetic engineering/GMO					○
Climate change				○	○
Corporate governance/business practices			○		○
Defense/military weapons	○	○	○	○	○
Employment equality/diversity	○		○	○	○
Environment	○		○		○
Environmental management systems			○	○	○
Environmental policies			○	○	○
Environmental reporting			○	○	○
Firearms					○
Fur					○
Gambling	○	○	○	○	○
Hazardous chemicals					
Healthcare/pharmaceutical marketing					○
Human rights	○		○	○	○
Indigenous peoples rights			○		
Intensive farming/factory farming					○
Labor relations/workplace conditions	○			○	○
Mining and quarrying			○		
Nuclear power			○		○
Other Islamic (Shari'ah) screens					○

(continued)

Table 4.3 (continued)

Social, environmental and ethical issues	SIF	EIRIS	Corporate monitor	KLD	VIGEO
Pornography/adult entertaintment					○
Beneficial product/services for life	○		○		○
Renewable/alternative energy			○	○	○
Sustainability				○	○
Tobacco	○	○	○	○	○
Tropical hardwood					○
Use of pesticides				○	○

Source: Perez-Gladish and M'Zali (2010)

In what follows, a further description on the three most renowned rating agencies, MSCI ESG STATS (former KLD Research & Analytics, Inc.), VIGEO and EIRIS is provided.

4.2.1 KLD

KLD offers in the United States, an aggregate rating of corporate social responsibility for more than 3,000 US companies. The KLD system allows American companies to be rated according to social criteria that are related to key stakeholders and are evaluated on the basis of strengths and concerns.

These criteria are grouped in three different dimensions: environment, social and governance. The environment dimension includes screens related to: climate change and clean technologies, pollution and toxics and other environment issues as recycling questions. Under the social dimension we have grouped screens related with community investment, diversity and Equal Employment Opportunities (EEO), human rights and labor relations. Last dimension, Governance concern relates to board issues. Screens included in a second component "Products and Processes" refer to the exclusion of investments related to production of alcohol, tobacco, or gambling products, known collectively as the "sin" screens, for over 60 years. Other popular negative screens taken into account refer to military weapons production, firearms, and nuclear power (see Table 4.4).

Table 4.5 displays the main social and environmental criteria in the dimensions and within the controversial business dimension.

As we have seen in Chap. 3, KLD social performance dimensions are used as a proxy for Corporate Social Responsibility (CSR) by most of the empirical research works: Mattingly and Berman (2006), Rehbein et al. (2004), Goss (2012), Bouslah et al. (2013), Bauer et al. (2009), Salama et al. (2011), and Oikonomou et al. (2012), are some recent examples.

KLD classifies the applied criteria in strength and concern applied to a company. For each KLD attributes it with a score of 1 if the criterion applies, and a score of

Table 4.4 Description of main SRI dimensions

Dimension	Description
Environmental, social and governance (ESG)	The United Nations Principles for Responsible Investment (UNPRI) was created in 2005 to provide a framework for incorporating Environment, Social and Governance (ESG) considerations into mainstream investment and ownership practices. ESG criteria measure Corporate Social Responsibility across a range of issues that impact a company's various stakeholders: environment, community & society, customers, employees & supply chain, governance & ethics
Products and services	It includes exclusion of investment in companies that participate in the production of alcohol, tobacco, or gambling products, known collectively as the "sin" screens, for over 60 years. Other popular negative screens include military weapons production, firearms, and nuclear power

0 in the opposite case. They do not aggregate strengths and concerns. Nevertheless, the majority of the scientific works, based primarily on the KLD database, use as an approximate measure of the firms' social performance an aggregate index of KLD strength and concerns. Some authors subtract the sum of concerns score from the sum of strengths score for each dimension obtaining in this way the total score associated with each KLD dimension. Other transform concern into strengths taking complementary binary values and finally, some authors consider separately strengths and concerns.

4.2.2 VIGEO

Regarding VIGEO, it was founded in 2002 in France and has established itself as the leading European expert in the assessment of companies and organizations concerning their practices and performance on environmental, social and governance (ESG) issues. Information provided by VIGEO facilitate financial analysts' work in obtaining a global view for ESG risks and opportunities, decisive to evaluate companies. It also allows investor clients to measure ESG performance and risks for their portfolios.

Table 4.5 Description of KLD's socially responsible criteria

Criteria	Description
Climate/clean tech	Investment in companies that have taken significant measures to reduce the contributions of their operations to global climate change and air pollution through the use of renewable energy, other clean fuels, or through the introduction of energy efficient programs or sale of products promoting energy efficiency
Pollution/toxics	Investment in companies which have strong pollution prevention programs, including both emissions and toxic-use reduction programs and that have a superior commitment to waste management programs
Environment/others	Investment in companies that are either a substantial user of recycled materials in its manufacturing processes, or major firms in the recycling industry. Superior commitment to management systems through ISO 14001 certification and other voluntary programs
Community investment	Investment in companies that have a remarkable community investment behavior: they have been generous in its giving inside/outside the U.S.; they are either a leader in their support for primary or secondary public school education, or they have offered significant support for youth job-training programs; they are prominent participant in public/private partnerships that support housing initiatives for the economically disadvantaged; they are strongly engaged in other positive community programs such as activity programs for the children, the older or the unemployed; they have a superior commitment in the improvement of the neighborhood;
	This criterion also takes into account penalty to companies which have recently been involved in major tax disputes involving Federal, state, local or non-U.S. government authorities, or are involved in controversies over their tax obligations to the community
Diversity & EEO	Investment in companies that have made substantive progress in the promotion of women and/or minorities to senior executive line positions; that have innovative hiring or other human resources programs for women and/or minorities, or that have a superior reputation as employers of women and/or minorities
Human rights	Investment in companies that have undertaken outstanding or innovative initiatives primarily related to labor rights in its supply chain outside the U.S.; that have established relations with indigenous peoples near its proposed or current operations (either in or outside the U.S.) that respect their sovereignty, land, culture, human rights, and intellectual property.
	This criterion also takes into account penalty to companies which have problems with human rights or directly support governments that systematically deny human rights
Labor relationships	Investment in companies that have strong health and safety programs; that have outstanding programs addressing employee work/life concerns; that have strong retirement benefits program; that have exceptional steps to treat its unionized workforce fairly; that strongly encourage employee involvement through active participation in management decision-making, and/or through ownership in the companies by granting stock options to a majority of their employees

(continued)

Table 4.5 (continued)

Criteria	Description
Board issues	Investment in companies that have fair executive pay policies consistent with industry norms and company's financial condition and that have governance policies that promote independence, accountability and transparency
Alcohol	Penalty to companies which license their company or brand name to alcohol products and/or manufacture or are involved in manufacturing alcoholic beverages including beer, distilled spirits, or wine and/or derive revenues from the distribution (wholesale or retail) of alcohol beverages
Animal testing	Investment in companies which use animals to test the toxicity of chemicals in consumer products as toiletries, tobacco or household cleaning products and/or use animals to test cosmetics
Defense/weapons	Penalty to companies which derive revenues from the sale of conventional weapons systems and/or ammunition or earned money from the sale of nuclear weapons or weapons systems
Gambling	Penalty to companies which produce goods and/or provide services related to gambling
Tobacco	Penalty to companies which license their company or brand name to tobacco products and/or produce tobacco products, including cigarettes, cigars, pipe tobacco, and smokeless tobacco products and/or derive revenues from the production and supply of raw materials and other products necessary for the production of tobacco products and/or derive revenues from the distribution (wholesale or retail) of tobacco

Source: KLD (2007)

Branches have expanded from its original French base, setting up subsidiaries in Belgium, Italy, Morocco, Japan, UK and Chile (120 people make up the VIGEO teams).

From the VIGEO activity report 2013: "Our renewed research on controversial activities includes thirty criteria to measure the level of implication in nine activity categories: armament, GMO, nuclear energy, alcohol, tobacco, gambling, animal maltreatment, hazardous chemicals and sex industry" (http://www.vigeo.com/).

VIGEO is a leading European expert in the assessment of companies and organizations with regard to their practices and performance on ESG issues. VIGEO has developed Equitics® a model based on internationally recognised standards to assess the degree to which companies under review take into account their social responsibility objectives in the definition and deployment of their strategy. They offer access to ratings in 6 dimensions, which are commonly used by the rating agencies: Human Rights; Human Resources; Environment; Business Behaviour; Corporate Governance and Community Involvement. These six dimensions are broken down into 17 non-financial criteria. A description of these criteria is presented in Table 4.6. Equitics® provides aggregated scores taking values from 0–100 for each social criterion.

Table 4.6 List of VIGEO's evaluation criteria

CORPORATE GOVERNANCE (CG): Effectiveness and integrity, guarantee of independence and efficiency of the Board of Directors, effectiveness and efficiency of auditing and control mechanisms, in particular the inclusion of social responsibility risks, respect for the rights of shareholders, particularly minority shareholders, transparency and rationale for the remuneration of directors	CG1. Board of directors
	CG2. Audit and internal controls
	CG3. Shareholders' rights
	CG4. Executive remuneration
BUSINESS BEHAVIOUR (BB): Consideration of the rights and interests of clients, integration of social and environmental standards in the selection of suppliers and on the entire supply chain, effective prevention of corruption and respect for competitive practices	BB1. Customer aspects (Product safety, Information to customers, Responsible Contractual Agreement)
	BB2. Integration of environmental and social factors in the supply chain
	BB3. Legal aspects (Prevention of corruption, Prevention of anti-competitive practices, Transparency and integrity)
ENVIRONMENT (ENV): Protection, safeguarding, prevention of damage to the environment, implementation of an adequate management strategy, ecodesign, protection of biodiversity and coordinated management of environmental impacts on the entire lifecycle of products and services	ENV1. Product pollution (Environmental strategy and ecodesign, Development of Green products and services, Protection of biodiversity)
	ENV2. Process pollution (water resources, atmospheric emissions, waste management environmental nuisances, management of environmental impacts from the process)
	ENV3. Management of environmental impacts from the use and disposal of products/services

HUMAN RESOURCES (HR): Continuous improvement of professional relations, labour relations and working conditions	HR1. Promotion of employee relations and participation
	HR2. Career management (career training and development, promotion of employability)
	HR3. Respect of labour conditions (working hours, remuneration, health and safety)
HUMAN RIGHTS AT THE WORKPLACE (HRts): Respect of freedom of association, the right to collective bargaining, non-discrimination and promotion of equally, elimination of illegal working practices such as child or forced labour, prevention of inhumane or degrading treatment such as sexual harassment, protection of privacy and personal data	HRts1. Respect for human rights standards and prevention of violations
	HRts2. Elimination of child labor, discrimination and forced labour
COMMUNITY INVOLVEMENT (CIN): Effectiveness, managerial commitment to community involvement, contribution to the economic and social development of territories/societies within which the company operates, positive commitment to manage the social impacts linked to products or services and overt contribution and participation in causes of public or general interest	CIN1. Promotion of social and economic development
	CIN2. Social impacts of company's products and services

4.2.3 EIRIS

Responsible investment services provided by EIRIS since 1983 are addressed to more than 200 clients including asset owners, asset managers, banks, stock brokers and governments around the world – as well as major index providers. Thanks to 11 international teams of researchers, EIRIS services cover 3,500 companies in nearly 50 countries. More than 110 different ESG areas are considered across 40 sectors researched. Over 1,000,000 ESG data points are analyzed. Climate change or water scarcity are some of the key areas taken into account. EIRIS introduced corporate governance criteria in 1996 and was the first research house to add detailed bribery indicators to its criteria from year 2008.

These independent agencies are aimed at supplying transparent and credible information about the social, labour and environmental performance of companies throughout the world, but few rating agencies monitor mutual funds for social responsibility criteria. Most of the rating agencies provide financial information about the funds and conventional investment strategy information and, although they also include some information related to the ethical investment strategy, the level of transparency and extension of the explanations differ from one agency to another. Actually, many of these agencies do not indicate if they allow indirect infringement of screens and those offering this information do not avoid minimum percentages and in any cases information about ethical competence of the investment company is provided.

Because of this, new rating measurements and the development of social indicators are required if the screening process wants to be changed. One step taken in this direction has been done by Natural Investments, which takes into account new socially responsible investment strategies, such as shareholder activism and community involvement. However, the non-financial rating for mutual funds is less developed than the financial counterpart and, to the knowledge of the authors of this chapter, very few academic studies can be found in the literature concerning mutual funds' socially responsibility performance measurement and non-financial rating. This claim is supported by a search in the SCOPUS and ABI/Inform Global databases, which was done by Perez-Gladish and M'Zali (2010) using the following search string: mutual funds, social performance, investment strategy and screening. The search prompted a total of 61 scholar papers and only 4 of them proposed a measure of mutual funds' social performance which could assist individual investors in their investment decision-making process. In what follows we revise the main characteristics of the main proposed measurements of mutual funds' social responsibility.

4.3 Academic Literature Review on the Measurement of Mutual Funds' Social Responsibility Degree

Mutual funds are the main SRI instrument. Their constitute a very heterogeneous group in terms of their social, environmental and ethical investment policy: number, type and implementation of applied non-financial screens; in terms of their engagement degree with shareholder resolutions; voting policy or, even with respect to the degree of transparency and credibility of the non-financial information provided to the investors (SRI research policy, expertise level of the fund managers, communication with companies and investors, external control etc.). However, this heterogeneity is not usually taken into account in the socially responsible performance measurement of SRI mutual funds, and according to Muñoz-Torres et al. (2004) the lack of harmonisation of social criteria among SRI funds is one of the main problems faced by financial managers.

Most of the works where some kind of social performance measure is proposed for mutual funds use a simple binary variable for just two social responsible categories (social responsible/non-social responsible funds) relying on mutual funds' self-classification into one of those categories. Very few studies can be found considering different degrees of social responsibility and, as screens are the most important tool for arriving at SRI, practitioners and authors often rely on this proxy as an indicator of mutual funds' social degree.

Most of the works in the academic literature propose screening intensity (the number of applied screens as a proxy of mutual funds' social performance degree). Therefore, the higher the number of applied screens, the higher social responsibility degree.

Basso and Funari (2003) consider two ethical categories (ethical/non-ethical funds) and they define a binary variable d, which is 0 if fund is not ethical and 1 if the fund is ethical. Ethical mutual funds are classified into several ethical categories, i.e., three categories such as ethical level 1 (low), ethical level 2 (average) and ethical level 3 (high). Basso and Funari (2003) propose using three binary variables d^1, d^2 and d^3 for each category. They base their ethical measurement for mutual funds on available public information about the ethical nature of the funds which is usually available and easy to obtain. This information gives rise to binary variables about the categorical nature of the fund, distinguishing between ethical/non-ethical funds and in the best case, takes into account the categorical nature of the ethical level (Table 4.7).

Table 4.7 Basso and Funari's ethical categories (Basso and Funari 2003)

Fund category	$d^{(1)}$	$d^{(2)}$	$d^{(3)}$
Non-ethical	0	0	0
Ethical level 1	0	0	1
Ethical level 2	0	1	1
Ethical level 3	1	1	1

Nevertheless Barnett and Salomon (2002) argue that it is important to recognise that socially responsible mutual funds differ substantially according to the severity of the ethical screens that they use. Allowing for this heterogeneity enables them to reconcile the divergent viewpoints on the performance of ethical funds in the extant literature.

Barnett and Salomon (2006) and Lee et al. (2010) use the screens proposed by the Social Investment Forum (SIF): alcohol, tobacco, gambling, defense/weapons, animal testing, product/service quality, environment, human rights, labor relations, employment equality, community investment, and community relations. The authors do not distinguish between positive or negative screening. They measure how screening intensity affects the financial performance of the SRI funds. Through the use of a set of dummy variables they provide information about the application of the different screens by the fund. The more screens applied the higher screening intensity and the higher the social performance. The same procedure is followed by Jegourel and Maveyraud (2010) who consider 16 negative screens identified by the EuroSIF: firearms, weapons and military, nuclear energy, tobacco, gambling, human rights violations, oppressive regimes, pornography, alcohol, animal testing, factory farming, furs, excessive environmental impact, GMO, products dangerous to health/environment and labor right violations.

Scholtens (2007) goes further and considers different screening types and degrees. He considers 22 negative criteria and 16 positive criteria. Negative criteria are grouped in “controversial products and services” or “controversial production methods or processes”. For the positive criteria he distinguishes three groups. First, a “general group” including: corporate governance, transparency, supply chain responsibility, and code of conduct. Second, a group named “environmental policies” and third, “social policies” group. In order to translate qualitative information about the screens employed into a simple quantitative measure Scholtens assigns each fund credits depending on the type of screen: 3 credits for exclusion in case of $>0\,\%$ of total sales derived from a certain activity; 2 credits for exclusion in case of $>5\,\%$ of total sales; and 1 credit for exclusion under certain conditions. In the case of positive screening he assigns 1 credit without making any distinction. For each mutual fund he computes their relative score (sum of obtained credits/total possible credits) and he uses this measure as a proxy for the social responsibility degree of the fund. Information on the screens of the funds is obtained from the annual reports of the invested funds.

Renneboog et al. (2008) consider not only the number but also the type of screens. The authors include in their model, through the use of a set of dummy variables, information on the fund presenting an activism policy, community involvement, in-house SRI research or if it is an Islamic fund, i.e. it is designed for Islamic investors.

On the other hand, Perez-Gladish and M'Zali (2010) propose an AHP-based ranking method for socially responsible mutual funds, which is not based on screening intensity. In Chap. 12 we will present this approach in detail. The authors rank funds based on a set of criteria directly related with the management of socially responsible mutual funds: investment policy, screening approach, engagement policy, research process, control of companies, external control, competence of fund managers and communication with companies and investors, among others. Perez-Gladish and M'Zali (2010) call these criteria "Quality of Information Related Criteria" (see Table 4.14) as they refer to the transparency and credibility of the non-financial information provided by the fund manager about SRI funds. More transparency and credibility seem to be needed to evaluate socially responsible mutual funds, given that information on their investment policies might not be available always and, when it is, its reliability might be questionable (Hoggett and Nahan 2002). Credibility could be improved by giving information about the existence and composition of an external controlling body and about if opinions of credible experts are considered, or by providing more data about the ethical competence of the investment company. In relation to this, Schwartz (2003) proposed a code of ethics for socially responsible investing regarding information disclosure, highlighting the necessity of making explicit criteria for screening decisions; the provision of moral justifications for screens; description of parties/individuals who apply criteria and how often screens are applied; the indication of which companies are being invested in (real-time), and so on. Koellner et al. (2005) suggested some other features related to the transparency and credibility of information: quality of the research method, diligence in carrying out research activities, overall accountability/compliance, dissemination of information and the impact on companies in the investment portfolio.

Muñoz-Torres et al. (2004) make a proposal for measuring social performance that would serve as an approximation for classifying and evaluating the CSR of SRI funds in Spain. Spanish Standardisation and Certification Association (AENOR) published in 2002 a standard entitled: "Requirements for Ethical and Socially Responsible Financial Instruments" (PNE 165001 EX) that specifies the requirements for ethical and socially responsible financial instruments created and sold by any organisation legally permitted to do so. The aim of this UNE standard is to certify that SRI investment products act in accordance with certain parameters and invest in companies also considered socially responsible. The standard includes two levels of requirements demanded of a financial instrument, so it can be considered SRI: the first level refers to basic, general criteria common to all SRI financial instruments; the second level specifically determines the intrinsic features with which each type of SRI financial instrument must comply.

From the literature review and existent practice we can observe the absence of a common basis for measuring mutual funds' social performance (Kaidonis 1999; Van Der Laan 2001; Goodpaster 2003). Investors seeking to invest in mutual funds including socially responsible criteria currently face an important lack of information. Scoring of mutual funds taking into account socially responsible criteria has an important practical relevance in portfolio selection.

From the review of the literature and according to the process followed by the main rating agencies, specially by KLD when rating US companies, we can identify a comprehensive list with a total of 41 screens which take into account Corporate Social Responsibility across a range of issues that impact a company's various stakeholders: environment, community and society, customers, employees and supply chain, governance and ethics. We have considered two different components: "Socially Responsible Investment Strategies" and "Quality of the information". Criteria within "Socially Responsible Investment Strategies" are mainly referred to Environment, Social and Governance issues (ESG) and controversial products and processes.

They are grouped in three different dimensions: environment, social and governance. The environment dimension includes screens related to: climate change and clean technologies, pollution and toxics and other environment issues as recycling questions. Under the social dimension we have grouped screens related with community investment, diversity and Equal Employment Opportunities (EEO), human rights and labor relations. Last dimension, governance concern relates to board issues. Screens included in a second component "Controversial Products and Processes" refer to the exclusion of investments related to production of alcohol, tobacco, or gambling products, known collectively as the "sin" screens, for over 60 years. Other popular negative screens taken into account refer to military weapons production, firearms, and nuclear power (see Tables 4.8–4.11 for detailed description of the screens).

The sources supporting the inclusion of each criterion has been reviewed in Perez-Gladish and M'Zali (2010), see Tables 4.12 and 4.13.

In addition to the above SEG criteria we can include a set of criteria related to the quality of the information provided by the mutual funds in terms of transparency and credibility of the information supporting social responsibility of the mutual fund provided by the fund manager and available to the general public. From literature review and current practice, 12 criteria have been considered. They take into account the type of research process, external control, intensity of screening approach and existence of an engagement policy and proxy voting (see Table 4.14).

Table 4.8 Social criteria

Criteria	Description
Community investment	Investment in companies that have been generous in its giving inside/outside the U.S.
	Investment in companies that are either a leader in their support for primary or secondary public school education, or the companies have offered significant support for youth job-training programs
	Investment in companies that are prominent participant in public/private partnerships that support housing initiatives for the economically disadvantaged
	Investment in companies that are strongly engaged in other positive community programs such as activity programs for the children, the older or the unemployed
	Investment in companies that have a superior commitment in the improvement of the neighborhood
	Non-acceptance of investments in companies which have recently been involved in major tax disputes involving Federal, state, local or non-U.S. government authorities, or are involved in controversies over their tax obligations to the community
Diversity & EEO	Investment in companies that have made substantive progress in the promotion of women and/or minorities to senior executive line positions
	The fund invests in companies that have innovative hiring or other human resources programs for women and/or minorities, or that have a superior reputation as employers of women and/or minorities
Human rights	Investment in companies that have undertaken outstanding or innovative initiatives primarily related to labor rights in its supply chain outside the U.S.
	Investment in companies that have established relations with indigenous peoples near its proposed or current operations (either in or outside the U.S.) that respect their sovereignty, land, culture, human rights, and intellectual property
	Non-acceptance of investments in companies that have problems with human rights or directly support governments that systematically deny human rights
Labor relationships	Investment in companies that have strong health and safety programs
	Investment in companies that have outstanding programs addressing employee work/life concerns
	Investment in companies that have strong retirement benefits program
	Investment in companies that have exceptional steps to treat its unionized workforce fairly
	Investment in companies that strongly encourage employee involvement through active participation in management decision-making, and/or through ownership in the companies by granting stock options to a majority of their employees

Source: Own elaboration based on KLD's indicators

Table 4.9 Environmental criteria

Criteria	Description
Climate/clean tech	Investment in companies that have taken significant measures to reduce the contributions of their operations to global climate change and air pollution through the use of renewable energy, other clean fuels, or through the introduction of energy efficient programs or sale of products promoting energy efficiency
	Non-acceptance of investments in companies which derive revenues from the sale of coal or oil and its derivative fuel products
	Investment in companies which derive substantial revenues from the development of innovative products with environmental benefits, including remediation products, environmental services, or products that promote the efficient use of energy
Pollution/toxics	Non-acceptance of investments in companies which manufacturer ozone depleting chemicals such as HCFCs, methyl chloroform, methylene chloride, or bromines
	Non-acceptance of investments in companies which are substantial producer of agricultural chemicals, including pesticides
	Non-acceptance of investments in companies which have substantial liabilities for hazardous waste, or has recently paid significant fines or civil penalties for waste management violations
	Non-acceptance of investments in companies which have recently paid substantial fines or civil penalties for, or it have a pattern of controversies regarding, violations of air, water, or other environmental regulations
	Non-acceptance of investments in companies whose emissions of toxic chemicals into the air and water from individual plants are notably high
	Investment in companies which have strong pollution prevention programs, including both emissions and toxic-use reduction programs
	Non-acceptance of investments in companies which are owners or operators of nuclear power plants, excluding electric utility co's
Environment/others	Investment in companies that are either a substantial user of recycled materials in its manufacturing processes, or major firms in the recycling industry
	Investment in companies that have demonstrated a superior commitment to management systems through ISO 14001 certification and other voluntary programs

Source: Own elaboration based on KLD's indicators

Table 4.10 Governance criteria

Criteria	Description
Board issues	Investment in companies that have fair executive pay policies consistent with industry norms and company's financial condition
	Investment in companies with governance policies that promote independence, accountability and transparency

Source: Own elaboration based on KLD's indicators

Table 4.11 Controversial products and processes criteria

Criteria	Description
Alcohol	Non-acceptance of investments in companies which license their company or brand name to alcohol products
	Non-acceptance of investments in companies which manufacture or are involved in manufacturing alcoholic beverages including beer, distilled spirits, or wine
	Non-acceptance of investments in companies which derive revenues from the distribution (wholesale or retail) of alcohol beverages
Animal testing	Non-acceptance of investments in companies which use animals to test the toxicity of chemicals in consumer products as toiletries, tobacco or household cleaning products
	Non-acceptance of investments in companies which use animals to test cosmetics
Defense/weapons	Non-acceptance of investments in companies which derive revenues from the sale of conventional weapons systems and/or ammunition or earned money from the sale of nuclear weapons or weapons systems
Gambling	Non-acceptance of investments in companies which produce goods and/or provide services related to gambling
Tobacco	Non-acceptance of investments in companies which license their company or brand name to tobacco products
	Non-acceptance of investments in companies which produce tobacco products, including cigarettes, cigars, pipe tobacco, and smokeless tobacco products
	Non-acceptance of investments in companies which derive revenues from the production and supply of raw materials and other products necessary for the production of tobacco products
	Non-acceptance of investments in companies which derive revenues from the distribution (wholesale or retail) of tobacco

Source: Own elaboration based on KLD's indicators

Table 4.12 Criteria to be taken into account in the measurement of mutual funds' social responsible performance

Criteria	Description	Authors
Investment policy (IP)	Clear description of the investment policy, how is developed and how the fund adhered to it	O'Rourke (2003), Hollingworth (1998), Basso and Funari (2003), Hayes (2005), and Michelson et al. (2004)
Screening approach (SA)	Type of screen: positive and/or negative, best-in-industry	O'Rourke (2003) and Michelson et al. (2004)
	Avoidance of minimum percentages for screens	Schepers and Sethi (2003), SIF (2001), Schlegelmilch (1997)
	Inclusion of indirect infringement of screens	Renneboog et al. (2008), Dillenburg et al. (2003), Barnett and Salomon (2006), Kempf and Osthoff (2008), Scholtens (2007), De Colle and York (2009), Goodpaster (2003), Hayes (2005), Hoggett and Nahan (2002), Kempf and Osthoff (2007), and Starr (2008)
Investment criteria (IC)	Indication of explicit criteria for screening decisions	Renneboog et al. (2008) and Goodpaster (2003)
	Provision of moral justifications for screens	Hoggett and Nahan (2002) and Michelson et al. (2004)
Engagement policy (EP)	Description of the aims of the engagement policy	Renneboog et al. (2008) and Hutton et al. (1998)
	How does the fund prioritise which companies it will engage? Engagement methods employed	
	How is the effectiveness of engagement activity monitored?	
	What further steps, if any, are taken if engagement is considered unsuccessful?	
	How, and how frequently, are engagement activities communicated to investors and other stakeholders?	
Voting policy (VP)	Does the fund have a voting policy? If so, what is it?	Renneboog et al. (2008) and Hutton et al. (1998)
	Does the fund disclose its voting practices and reasoning for decisions? If so, where can this information be found?	
	Does the fund sponsor/co-sponsor shareholder resolutions?	

Table 4.13 Criteria to be taken into account in the measurement of mutual funds' social responsible performance

Criteria	Description	Authors
Research process (RP)	Describe SRI research methodology and process	Michelson et al. (2004) and Hollingworth (1998)
	Does the fund manager use an in-house research team and/or an external research team?	Hoggett and Nahan (2002), Tippet (2001), Schlegelmilch (1997), and Schwartz (2003)
	Is there an external control or external verification process in place for the research process? Where an Advisory Committee is used, description of responsibilities	Schrader (2006), Koellner et al. (2005), Chatterji et al. (2009), Dillenburg et al. (2003), Dunfee (2003), O'Rourke (2003), and Waddock (2003)
	How frequently is the research process reviewed?	
	What research findings are disclosed to the public? How?	
Selection process (SP)	Indicate how often screens are applied	Michelson et al. (2004)
	Indicate in real-time which companies are being invested in	Schrader (2006), Koellner et al. (2005), and Chatterji et al. (2009)
	Indicate how conflicts between bottom-line considerations versus screens will be resolved	O'Rourke (2003)
	How are the results of research integrated into the investment process, including selection and approval of companies for investment?	
	What is the policy and procedure for divestment on SRI grounds?	
Control companies (CC)	Description of communication with companies in order to control for the verification of selection criteria	Michelson et al. (2004), Schrader (2006), Koellner et al. (2005), and Kempf and Osthoff (2008)
	Does the fund manager inform companies of portfolio exclusions or divestment due to non-compliance with its SRI policy and criteria?	Chatterji et al. (2009) and Goodpaster (2003)
	What internal or external measures are in place to ensure portfolio holdings comply with SRI criteria?	
	Do companies have the opportunity to see their profile or analysis? If yes, how often?	

Table 4.14 Quality of information criteria

Criteria	Description
Investment policy	Description of the funds' investment policy with regards to socially responsible issues
Screening approach	Type of screen: Positive and/or negative. Degree of allowed infringement
Investment criteria	Indication of the explicit criteria for investment. Provision of moral justification for the screens
Engagement policy	Description of the aims of the engagement policy. How does the fund prioritize which companies it will engage with? Engagement employed methods. How is the effectiveness of engagement activity monitored? What further steps, if any, are taken if engagement is considered unsuccessful? How, and how frequently, are engagement activities communicated to investors and other stakeholders? Does the fund have a voting policy? If so, what is it? Does the fund disclose its voting practices and reasoning for decisions? If so, where can this information be found? Does the fund sponsor/co-sponsor shareholder resolutions?
Voting policy	Existence of a voting policy. Sponsorship of shareholder resolutions
Research process	Does the fund manager use an in-house research team and/or an external research team? Is there an external control or external verification process in place for the research process? Where an Advisory Committee is used, description of responsibilities. How frequently is the research process reviewed? What research findings are disclosed to the public? How?
	Some funds have their own internal research team analyzing company activities in order to indentify suitable investments. Other use external research providers such as rating agencies to get that information. In the case of an independent ethical committee it is necessary to know if it has the ultimate say on policy changes and company investments or if it delegates the responsibility to the fund manager
Selection process	Description of divestment processes. Indication of how often the screens are applied. Real-time information about investments
Control company	Communication with companies. Information for companies of portfolio exclusions. Internal and/or external measures application to ensure portfolio holdings comply with SRI criteria
Experts' opinion	Experts advising investment decisions
External control	Engage in an ethical audit of fund periodically. Signature of transparency guidelines
Competence of the fund manager	Provision of information about the SRI education of the fund manager
Communication with investors	Clear and periodical communication with investors about previous issues

Source: Own source based on Perez-Gladish and M'Zali (2010)

4.4 A First Proposal for the Measurement of Assets' Social Responsibility Degree

From previous sections we can conclude that the definition of socially responsible performance needs a clear understanding of fundamental criteria. From the previously presented revision of the literature and the current practice, we identified two different main dimensions on *Social Responsibility Degree (SRD)* measurement: a dimension related to the "Socially Responsible Investment Strategies" followed by the fund manager and a "Quality of Information" dimension related to transparency and credibility of the information provided by the mutual fund manager.

In this section, and following actual trends of practitioners and academics, we will focus on the main Socially Responsible Investment Strategy followed by mutual funds: screening (positive and/or negative). In following chapters, we will propose different alternative approaches to the one presented in this first part of the book, which will contribute to enrich it and/or complement it.

Assessment of mutual funds' Social Responsibility Degree is, due to the ambiguous, imprecise and/or uncertain character of the considered dimensions and variables, a difficult question. A large amount of information is available but data are, in most of the cases, imprecise, ambiguous and with a high degree of associated uncertainty. It is difficult to verify if the information provided is trustable or not as very few control systems exist in order to guarantee the transparency and credibility of non-financial data.

On the other hand, and as we have seen in previous sections, no clear measures, rules and/or processes exist in order to evaluate the degree of environmental, social, ethical and/or governance responsibility of a mutual fund.

Fuzzy Sets Theory offers some elements which can help decision makers to assess the social responsibility degree of mutual funds, since it provides suitable tools for dealing with uncertainty and imprecision in data and it facilitates the incorporation of expert knowledge from the DM, which is in most of the cases of subjective character. Chapter 14 will present a measurement approach which takes into account the imprecise and fuzzy nature of social responsibility issues. In what follows, we will propose a first approach based on the precise or crisp data provided by the rating agencies.

4.4.1 Aggregated Social Responsibility Indicator

In this first approach, three steps have been taken into account. In a first step, and from the literature review and the current practice of rating agencies, we identify the main criteria affecting SRI decisions and we propose quantitative performance indicators for each one of the criteria considered.

The indicators proposed take into account different screening strategies and different social, environmental, governance and ethical features. In the second step, we aggregate the individual indicators in order to measure the socially responsible performance of the mutual funds. With this aim, preferential subjective weights from a fictitious investor are obtained. Through these weights, the investor is able to reflect the importance he is willing to give to the different social responsibility dimensions (environment, social, governance…) and to the different SRI strategies (negative and/or positive screening).

In the third step, a SRI expert, who is the person in charge of the mutual funds evaluation process, weighs the different quality of non-financial information indicators which will serve as a proxy of the transparency and credibility of the information on the screening process and of the degree of SRI expertise of the mutual fund manager (see Fig. 4.1).

Let us consider a set of mutual funds $\{F_i\}_{i=1}^n$ and a set of social responsibility screens $\{S_j\}_{j=1}^m$. Each mutual fund ($i = 1, \ldots, n$) is evaluated with respect to each screen ($j = 1, \ldots, m$) using the following binary variables:

$$s_{ij} = \begin{cases} 0 & \text{if the fund } i \text{ does not apply the screen } j \\ 1 & \text{otherwise} \end{cases}$$

Definition 4.1 The *screening intensity* of a mutual fund i, denoted by SI_i, is defined as:

$$SI_i = \sum_{j=1}^{m} \frac{w_j s_{ij}}{m}, \quad w_j \in [0,1], \quad SI_i \in [0,1],$$

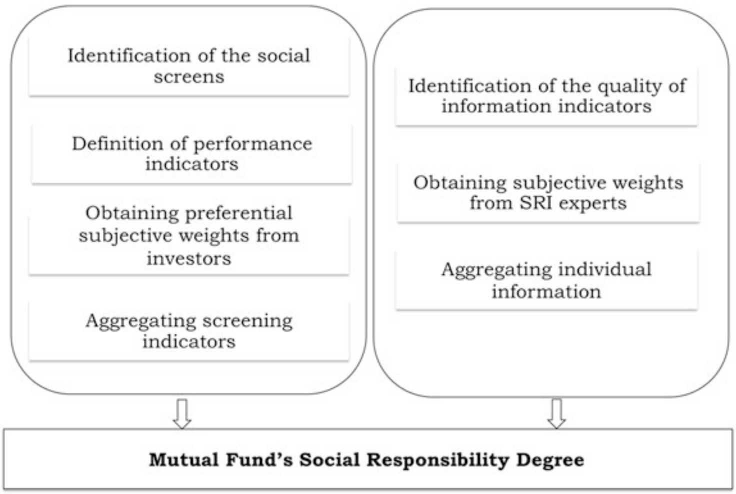

Fig. 4.1 Construction of an aggregated social responsibility indicator (Mendez-Rodriguez et al. 2013)

where w_j are preferential weights which reflect the importance given by the investor to each screen j.

Let us consider a set of indicators for the quality of the non-financial information provided by the mutual funds, $\{Q_k\}_{k=1}^{l}$. Each mutual fund ($i = 1, \ldots, n$) is evaluated with respect to each of these indicators ($k = 1, \ldots, l$) using the following binary variables:

$$q_{ik} = \begin{cases} 0 & \text{if the fund } i \text{ does not accomplish indicator } k \\ 1 & \text{otherwise} \end{cases}$$

Definition 4.2 The *quality of the non-financial information* provided by a mutual fund i, denoted by QI_i, is defined as:

$$QI_i = \sum_{k=1}^{l} \frac{\lambda_k q_{ik}}{k}, \quad \lambda_k \in [0, 1], \quad QI_i \in [0, 1],$$

where λ_k are preferential weights which reflect the importance given by the SRI expert to each quality of information indicator k.

This indicator, QI_i, will have a rewarding/penalizing effect on the screening intensity as the number of applied screens is not a sufficient indicator by itself of the social responsibility degree of a mutual fund due to the usual lack of information on the screening process. We will assume that the effect of this rewarding/penalizing factor on the screening intensity is multiplicative.

Definition 4.3 The *Social Responsibility Degree* of mutual fund i, denoted by SRD_i, is defined as:

$$SRD_i = SI_i \cdot QI_i \quad SRD_i \in [0, 1].$$

Thus, if $QI_i = 0$, this factor will have a penalizing effect on the fund and therefore, its Social Responsibility Degree, SRD_i, will be zero (it does not matter how many screens are applied by the fund if the quality of the information with respect to the screening process is zero). On the other hand, if $QI_i = 1$, we will be rewarding the screening process and we will accept the screening intensity, SI_i, as a good proxy of the Social Responsibility Degree, SRD_i, of the mutual fund.

4.4.2 Applying SRD Indicator to a Real World Case Study

In what follows, and in order to illustrate the proposed approach, an empirical study is presented on 110 U.S. domiciled large cap equity mutual funds (conventional and socially responsible mutual funds members of the Social Investment Forum (SIF)).

Our database is composed of both, conventional and socially responsible mutual funds. The set of socially responsible mutual funds (25 mutual funds) consists of all the large cap equity mutual funds which are members of the SIF.

For the conventional mutual funds, our initial database, provided by Morningstar Ltd, consisted of 10,038 open end U.S. large cap equity mutual funds. We applied a filter to this database in order to obtain the set of funds with complete weekly return data from 8/22/2000 to 8/21/2010.

The applied filter gave rise to a set of 1,505 mutual funds. Our random sample consists of around 5 % of this last set of funds, i.e. 85 conventional U.S. large cap equity mutual funds with inception date prior to 22/08/2000 and complete weekly return data for the 10 year period. In order to measure the degree of Socially Responsibility of mutual funds, we will take into account 41 screens grouped into four dimensions and 8 indicators for the quality of the non-financial information. The definition of these screens is based on KLD's criteria (see Tables 4.15–4.18 for a description of each screen and indicator). We will check the information displayed by the mutual funds in the Social Investment Forum website, now known as Forum for Sustainable and Responsible Investment, US SIF (http://www.ussif.org/).

From the information provided by the mutual funds and available at the Social Investment Forum (SIF) website, we can observe how all the socially responsible mutual funds seek to invest in companies which derive some proportion of the revenues from the development of innovative products with environmental benefits; most of the funds invest in companies that have taken measures to reduce the contribution of their operations to global climate change; funds also seem to avoid investing in companies which produce hazardous waste. It is interesting to observe that no one of the funds explicitly mention to invest in companies that have demonstrated a superior commitment to management systems through ISO 14001 certification and other voluntary programs. Most of the issues of concern are related to climate change and clean technologies, development of innovative products with environment benefits and avoiding of investments in companies which have liabilities for hazardous waste.

All the socially responsible mutual funds studied invest in companies that have innovative hiring or other human resource programs for minorities. The 25 funds avoid investing in companies that have problems with human rights or directly support governments that systematically deny human rights. Most of the funds give also importance to investments in companies which have a good relationship with their unionized workforce. Most of the funds invest in companies with good corporate governance practices. The funds seek to invest in companies with a fair executive pay policy and with governance policies that promote independence, accountability and transparency.

All the funds exclude from their investments companies manufacturing alcohol beverages. Funds F18–F24 also avoid investing in companies that distribute alcohol or license their company or brand name to alcohol products. Almost all the funds restrict investment in companies involved in animal testing. Funds F20 and F21 explicitly recognizes that medical products are required to undergo animal testing in compliance with the FDA. All funds avoid investing in companies which derive

Table 4.15 Environmental screens (positive + or negative −) and descriptors of performance

Environment				Yes	No
A. Climate/clean tech	+	A1	The fund invests in companies that have taken significant measures to reduce the contributions of their operations to global climate change and air pollution through the use of renewable energy, other clean fuels, or through the introduction of energy efficient programs or sale of products promoting energy efficiency		
	−	A2	The funds avoid investing in companies which derive revenues from the sale of coal or oil and its derivative fuel products		
	+	A3	The fund invests in companies which derive substantial revenues from the development of innovative products with environmental benefits, including remediation products, environmental services, or products that promote the efficient use of energy		
B. Pollution/toxics	−	B1	The fund avoids investing in companies which manufacturer ozone depleting chemicals such as HCFCs, methyl chloroform, methylene chloride, or bromines		
	−	B2	The fund avoids investing in companies which are substantial producer of agricultural chemicals, including pesticides		
	−	B3	The fund avoids investing in companies which have substantial liabilities for hazardous waste, or has recently paid significant fines or civil penalties for waste management violations		
	−	B4	The fund avoids investing in companies which have recently paid substantial fines or civil penalties for, or it have a pattern of controversies regarding, violations of air, water, or other environmental regulations		
	−	B5	The fund avoids investing in companies whose emissions of toxic chemicals into the air and water from individual plants are notably high		
	+	B6	The fund invests in companies which have strong pollution prevention programs, including both emissions and toxic-use reduction programs		
	−	B7	The fund avoids investing in companies which are owners or operators of nuclear power plants, excluding electric utility co's		
C. Environment/others	+	C1	The fund invests in companies that are either a substantial user of recycled materials in its manufacturing processes, or major firms in the recycling industry		
	+	C2	The fund invests in companies that have demonstrated a superior commitment to management systems through ISO 14001 certification and other voluntary programs		

Source: Mendez-Rodriguez et al. (2013)

Table 4.16 Social screens (positive + or negative −) and descriptors of performance

Social				Yes	No
D. Community investment	+	D1	The fund invests in companies that have been generous in its giving inside/outside the U.S.		
	+	D2	The fund invests in companies that are either a leader in their support for primary or secondary public school education, or the companies have offered significant support for youth job-training programs		
	+	D3	The fund invests in companies that are prominent participant in public/private partnerships that support housing initiatives for the economically disadvantaged		
	+	D4	The fund invests in companies that are strongly engaged in other positive community programs such as activity programs for the children, the older or the unemployed		
	+	D5	The fund invests in companies that have a superior commitment in the improvement of the neighbourhood		
	−	D6	The fund avoids investing in companies which have recently been involved in major tax disputes involving Federal, state, local or non-U.S. government authorities, or are involved in controversies over their tax obligations to the community		
E. Diversity & EEO	+	E1	The fund invests in companies that have made substantive progress in the promotion of women and/or minorities to senior executive line positions		
	+	E2	The fund invest in companies that have innovative hiring or other human resources programs for women and/or minorities, or that have a superior reputation as employers of women and/or minorities		
F. Human rights	+	F1	The fund invests in companies that have undertaken outstanding or innovative initiatives primarily related to labour rights in its supply chain outside the U.S.		
	+	F2	The fund invests in companies that have established relations with indigenous peoples near its proposed or current operations (either in or outside the U.S.) that respect their sovereignty, land, culture, human rights, and intellectual property		
	−	F3	The fund avoids investing in companies that have problems with human rights or directly support governments that systematically deny human rights		

(continued)

Table 4.16 (continued)

Social				Yes	No
G. Labour relationships	+	G1	The fund invests in companies that have strong health and safety programs		
	+	G2	The fund invests in companies that have outstanding programs addressing employee work/life concerns		
	+	G3	The fund invests in companies that have strong retirement benefits program		
	+	G4	The fund invests in companies that have exceptional steps to treat its unionized workforce fairly		
	+	G5	The fund invests in companies that strongly encourage employee involvement through active participation in management decision-making, and/or through ownership in the companies by granting stock options to a majority of their employees		

Source: Mendez-Rodriguez et al. 2013

revenues from the sale of conventional weapons systems and/or ammunition or earned money from the sale of nuclear weapons or weapons systems. All the funds avoid investing in companies which produce goods and/or provide services related with gambling and avoid investing in companies which manufacture tobacco products.

Once each mutual fund ($i = 1, \ldots, 100$) has been evaluated with respect to each screen ($j = 1, \ldots, 41$) and with respect to each quality of information indicator ($k = 1, \ldots, 8$), we measure their Social Responsibility Degree. Table 4.19 displays Mutual Funds' Social Responsibility Degree (SRD_i). We have also calculated the Social Responsibility Degree when only negative screening is considered as investment strategy (denoted by SRD_i^{neg}) and for the case in which only positive screening is taken into account (denoted by SRD_i^{pos}).

Dhaliwal et al. (2011) show that firms with high corporate social responsible rates tend to disclose more information than the ones with low rates, given that these firms want to reflect a positive image to investors and other stakeholders. This is consistent with the obtained results in this work where funds with the higher score for the quality of information indicator (F25, F17, F22, F23) are also the ones obtaining higher scores on the degree of social responsibility (see Tables 4.19 and 4.20).

Table 4.17 Governance and products and processes screens (positive + or negative −) and descriptors of performance

Governance				Yes	No
H. Board issues	+	H1	The fund invests in companies that have fair executive pay policies consistent with industry norms and company's financial condition		
	+	H2	The fund invests in companies with governance policies that promote independence, accountability and transparency		
Products and processes				Yes	No
I. Alcohol	−	I1	The fund avoids investing in companies which license their company or brand name to alcohol products		
	−	I2	The fund avoids investing in companies which manufacture or are involved in manufacturing alcoholic beverages including beer, distilled spirits, or wine		
	−	I3	The fund avoids investing in companies which derive revenues from the distribution (wholesale or retail) of alcohol beverages		
J. Animal testing	−	J1	The fund avoids investing in companies which use animals to test the toxicity of chemicals in consumer products as toiletries, tobacco or household cleaning products		
	−	J2	The fund avoids investing in companies which use animals to test cosmetics		
K. Defense/weapons	−	K1	The fund avoids investing in companies which derive revenues from the sale of conventional weapons systems and/or ammunition or earned money from the sale of nuclear weapons or weapons systems		
L. Gambling	−	L1	The fund avoids investing in companies which produce goods and/or provide services related to gambling		
M. Tobacco	−	M1	The fund avoids investing in companies which license their company or brand name to tobacco products		
	−	M2	The fund avoids investing in companies which produce tobacco products, including cigarettes, cigars, pipe tobacco, and smokeless tobacco products		
	−	M3	The fund avoids investing in companies which derive revenues from the production and supply of raw materials and other products necessary for the production of tobacco products		
	−	M4	The fund avoids investing in companies which derive revenues from the distribution (wholesale or retail) of tobacco		

Source: Mendez-Rodriguez et al. (2013)

Table 4.18 Description of "Quality of Information" indicators

Quality of information provided by mutual funds: transparency & credibility			Yes	No
N. Screening approach	N1	The fund indicates the explicit criteria for screening decisions		
	N2	The fund applies social screening first, then financial screening		
O. Advocacy & public policy	O1	The fund has a proxy voting policy and discloses voting practices and reasoning for decisions		
	O2	The fund sponsor/co-sponsors shareholder resolutions		
P. Research process	P1	The fund presents a description of its SRI research methodology and process		
	P2	The fund has its own internal research team composed by experts in SRI analyzing company activities in order to identify suitable investments		
	P3	The fund uses external research expert providers such as rating agencies to get that information.		
Q. External control	Q1	The fund is engaged in an ethical external audit periodically		

Table 4.19 Mutual funds' social responsibility degree based on the followed investment strategy

Family	Funds	QI_i	SRD_i	SRD_i^{neg}	SRD_i^{pos}
Calvert	F1–F16	0.625	0.088	0.188	0.139
Domini	F17	0.750	0.125	0.357	0.220
Green century	F18	0.625	0.172	0.268	0.416
MMA praxis	F19	0.500	0.150	0.167	0.265
Neuberger berman	F20–21	0.500	0.150	0.167	0.159
Parnassus	F22–F23	0.875	0.244	0.286	0.265
Sentinel	F24	0.500	0.175	0.262	0.220
Walden	F25	0.875	0.284	0.542	0.416
Other	F26–F110	0	0	0	0

Table 4.20 Mutual funds' social responsibility degree based on different socially responsible dimensions

Family	Funds	SRD_i^{env}	SRD_i^{soc}	SRD_i^{gov}	SRD_i^{prod}
Calvert	F1–F16	0.156	0.234	0.625	0.341
Domini	F17	0.313	0.516	0.375	0.409
Green century	F18	0.313	0.313	0.000	0.511
MMA praxis	F19	0.125	0.125	0.000	0.500
Neuberger berman	F20–21	0.125	0.125	0.000	0.500
Parnassus	F22-F23	0.219	0.273	0.875	0.875
Sentinel	F24	0.125	0.219	0.500	0.455
Walden	F25	0.219	0.219	0.438	0.477
Other	F26–F110	0	0	0	0

Conclusions

We have here focused on the way of aggregating information on SRI strengths and concerns of financial assets. To this end, an aggregated indicator of the social responsibility degree of each asset can be subjectively or objectively constructed. A first proposal for the construction of this indicator based on a subjective method is the primary objective of this chapter. After reviewing the literature, we can state that this concern has not been fully addressed. One of the main problems faced by financial managers is the lack of harmonization of social criteria among SRI funds, as they constitute a very heterogeneous group with respect to social, environmental, ethical investment/voting policy, engagement degree with shareholders resolutions. When developing the aggregated social responsibility indicator, we focus on the main Socially Responsible Investment Strategy followed by mutual funds: positive and/or negative screening introducing, by means of a correcting factor, the degree of transparency and credibility of the non-financial information. The proposed approach is based on the precise or crisp data provided by the rating agencies. With the aim of illustrating the proposed approach, an empirical study is presented on 110 conventional and socially responsible mutual funds members of the Social Investment Forum. Also in this chapter, the two stages of the "Social Auditing Process" are examined, paying particular attention to the key independent agencies' role.

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Part II
Goal Programming and SRI Funds

Chapter 5
Portfolio Selection by Goal Programming Techniques

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Abstract Goal programming stems from the Simonian paradigm describing decision makers as seekers of satisfying solutions rather than optimal solutions. Weighted Goal Programming (WGP) is usually viewed as a deterministic model, which provides satisfying solutions to multi-objective technological and economic problems in multiple criteria decision making analysis. Deterministic WGP is less appropriated to select securities portfolios because returns on securities are random variables. To accommodate WGP to portfolio selection, some stochastic versions of different strictness had been proposed. In this chapter, we deal with Mean-Variance Stochastic Goal Programming (MV-SGP) model, which relies on classic expected utility maximization theory, also known as Eu(R), Arrow's risk aversion and Pratt's approximation to expected utility.

5.1 Deterministic Weighted Goal Programming

Goal Programming is a subfield of MCDM techniques and its defined as a multi-objective programming approach. The idea underlying Goal Programming (Charnes and Cooper 1977) is to search for a "satisfying" set of actions in a framework of Simonian bounded rationality and multiple objectives (Steuer 1986). This search is accomplished by establishing the achievement function or objective function, trying to conciliate the achievement of the set of goals rather than actually attempting to optimize each and every goal. Before Charnes and Cooper, some other author searched for a broader view of GP (Ijiri 1965; Lee 1972; Ignizio 1976). As a multiple criteria approach to decision making, GP advises a "satisfying" trade-off between the goals. In this way, GP provides an alternative representation that often is more effective in capturing the nature of real world problems.

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The most usual GP approaches are deterministic Weighted Goal Programming (WGP), lexicographic GP (Lee 1972), minmax GP, and multigoal programming. Since 1970s, a wide number of theoretical and practical developments has been developed. A significant contribution to the field of GP is Romero (1991). Practical applications are included in Jones and Tamiz (2010).

WGP is stated as follows:

$$\min D = \sum_{j=1}^{n} \frac{w_j (w_j^+ d_j^+ + w_j^- d_j^-)}{b_j}$$
$$b_j \neq 0 \quad w_j^+ + w_j^- = 1 \quad \forall j; \quad \sum_{j=1}^{n} w_j = 1 \tag{5.1}$$

subject to the following goal constraints:

$$\sum_{i=1}^{m} a_{ij} x_i = b_j + d_j^+ - d_j^-; \quad j = 1, 2, \ldots, n \tag{5.2}$$

together with $x_i \geq 0, \quad \forall i$, where,

x_i is the ith output (decision variable)
a_{ij} is the per unit cost of the ith output for the jth goal
b_j is the target or aspiration level for the jth goal
And d_j^+ are the jth positive and negative deviations, respectively, from the jth target
w_j, w_j^+ and w_j^- are preference weights attached to the jth deviation

In objective function (5.1), each deviation is normalized by the respective b_j target.

A slightly modified version of model (5.1)–(5.2) is as follows. Make $W_j^+ = w_j\, w_j^+$ and $W_j^- = w_j\, w_j^-$. Then, the model becomes:

$$\min D = \sum_{j=1}^{n} \frac{W_j^+ d_j^+ + W_j^- d_j^-}{b_j}$$

where the sum of weights are equal to 1, subject to goal constraints (5.2) and the non-negativity conditions, where:

$$\sum_{j=1}^{n} (W_j^+ + W_j^-) = \sum_{j=1}^{n} w_j (w_j^+ + w_j^-) = 1$$

An example of deterministic WGP in the SRI context is as follows. Let F_1 and F_2 be two assets whose weekly returns are observed on the stock market over the 4 last years. From this reliable information, the following parameters are obtained:

$$E_1 = 0.19; \quad E_2 = 0.27; \quad \sigma_1 = 0.030; \quad \sigma_2 = 0.042; \quad \sigma_{12} = 0.98;$$

where,

E_1 and E_2 are the expected returns of F_1 and F_2, respectively.
σ_1 and σ_2 are the respective standard deviations.
σ_{12} is the correlation coefficient between returns on F_1 and F_2.

To select a portfolio F whose components are assets F_1 and F_2, the following parameters are stated:

$E_F = E_1 x_1 + E_2 x_2$
$\sigma_F^2 = \sigma_1^2 x_1^2 + \sigma_2^2 x_2^2 + 2\sigma_1\sigma_2\sigma_{12} x_1 x_2 \cong (\sigma_1 x_1 + \sigma_2 x_2)^2$, namely, $\sigma_F \cong \sigma_1 x_1 + \sigma_2 x_2$
$P_F = p_1 x_1 + p_2 x_2$
$Q_F = q_1 x_1 + q_2 x_2$

where,

x_1 and x_2 are the portfolio weights; $x_1 + x_2 = 1$
E_F is the portfolio expected return
σ_F is the portfolio standard deviation
P_F is the portfolio index of social responsibility
Q_F is the portfolio index of environmental responsibility
$p_1 = 0.15$ and $p_2 = 0.07$ are indexes of social responsibility for F_1 and F_2 respectively
$q_1 = 0.24$ and $q_2 = 0.12$ are indexes of environmental responsibility for F_1 and F_2 respectively

From this information, model (5.1)–(5.2) is stated as follows.

$$\min D = \frac{0.3\,(0.5d_1^+ + 0.5d_1^-)}{0.22} + \frac{0.3\,(0.5d_1^+ + 0.5d_1^-)}{0.034} + \\ + \frac{0.2\,(0.5d_1^+ + 0.5d_1^-)}{0.12} + \frac{0.2\,(0.5d_1^+ + 0.5d_1^-)}{0.16} \tag{5.3}$$

subject to the following constraints,

$$0.19x_1 + 0.27x_2 = 0.22 + d_1^+ - d_1^- \tag{5.4}$$

$$0.030x_1 + 0.042x_2 = 0.034 + d_2^+ - d_2^- \tag{5.5}$$

$$0.15x_1 + 0.07x_2 = 0.12 + d_3^+ - d_3^- \tag{5.6}$$

$$0.24x_1 + 0.12x_2 = 0.16 + d_4^+ - d_4^- \tag{5.7}$$

$$x_1 + x_2 = 1 \tag{5.8}$$

$$x_1 \geq 0, \quad x_2 \geq 0$$

where 0.22, 0.034, 0.12, and 0.16 are the respective targets, while 0.3, 0.3, 0.2, and 0.2 are the respective preference weights.

By using LINGO, this model is solved, thus obtaining the following portfolio weights:

$x_1 = 0.625; x_2 = 0.375$

Deviations from the targets are equal to zero except, $d_2^+ = 0.005$ and $d_4^+ = 0.035$.

Either in purely financial or in ethical financial portfolio choice, WGP is not a suitable method. Concerns are as follows.

(i) Portfolio selection requires computing times series of returns from daily prices observed on the Stock Exchange. Prices and returns are random variables governed by probability distributions, either normal distributions or others. Due to randomness, portfolio selection should be addressed by stochastic models rather than by deterministic WGP models. Later in this chapter, we will return on this critical issue.

(ii) In finance, classical risk measures such as portfolio variance and semivariance are quadratic. These measures are inappropriate to be introduced into deterministic WGP model (5.1)–(5.2), whose goal equations are linear. In MCDM analysis, linear measures of risk have been proposed to replace the quadratic one, but these controversial proposals are not easily acceptable in financial literature beyond OR papers. Obviously, our illustrative example of portfolio choice with two stocks is a mere didactic example in which the portfolio variance becomes linear because returns on the two stocks are highly correlated between one another. There are reasons to think that risk should be measured by quadratic functions. An example outside the financial field is as follows. If you are driving your car 100 km/h, then risk of road accidents reaches level R. If you drive 200 km/h, then risk increases to R'. Consider the following alternative hypotheses: (a) $R' = 2R$, which involves linear risk; (b) $R' = 4R$, which involves quadratic risk. To test these hypotheses is interesting. Statistical surveys can say something about them, but one can sensibly think that $R' = 4R$ is more realistic than $R' = 2R$.

(iii) Another concern with linear measure of the portfolio risk arises from the co-movement question. In financial language, co-movement means correlation between returns on assets. Suppose, for the sake of simplicity, a portfolio with only two assets. A quadratic measure of risk is portfolio variance V, which is stated as follows:

$$V = \sigma_1^2 x_1^2 + \sigma_2^2 x_2^2 + 2\sigma_1\sigma_2\rho_{12}x_1x_2$$

where correlation coefficient ranges between (−1) and 1. Consider the infrequent case of maximum co-movement. Then, $\rho_{12} = 1$, so that measure V becomes:

$$V^* = \sigma_1^2 x_1^2 + \sigma_2^2 x_2^2 + 2\sigma_1\sigma_2 x_1 x_2 = (\sigma_1 x_1 + \sigma_2 x_2)^2$$

or equivalently,

$$V^{*1/2} = \sigma_1 x_1 + \sigma_2 x_2$$

Suppose that we use a linear measure such as:

$$L = \sigma_1 x_1 + \sigma_2 x_2$$

to evaluate the portfolio risk whatever the co-movement level. Measures L and $(V^*)^{1/2}$ are the same. Therefore, if we use L to measure the portfolio risk, then we are implicitly assuming that there always is maximum co-movement, an absurd assumption indeed.

To sum up, portfolio selection by deterministic WGP relays on unrealistic assumptions, which are not easily accepted in financial analysis.

5.2 An Example of SRI Decisions

Consider a company interested in training middle and top level managers in activities such as investment control and SRI (environmental) management. This training is taking place in three countries $i = 1, 2, 3$. There are four departments which are engaged in this training program. These are labeled as follows: $j = 1$ (teaching in investment control), $j = 2$ (teaching in SRI management), $j = 3$ (administration), $j = 4$ (staff responsible for the program). Their respective budget costs are computed weekly. Therefore, we should initially consider four goals, each corresponding to a budget. They are collectively termed *budget goals*. In some approaches below, we also consider three more goals to reflect necessities of managers for each country. They are collectively termed *manager goals*. Targets b_j and preference weights w_j will be specified.

In our context, WGP is stated as follows:

(i) Budget goal equations:

- For teaching in investment control

$$\sum_{i=1}^{3} a_{i1} x_i = 2.12x_1 + 1.97x_2 + 1.53x_3 = 5{,}400 + d_1^+ - d_1^-$$

- For teaching in SRI management

$$\sum_{i=1}^{3} a_{i2}x_i = 2.10x_1 + 2.55x_2 + 1.89x_3 = 9{,}200 + d_2^+ - d_2^-$$

- For administration

$$\sum_{i=1}^{3} a_{i3}x_i = 0.92x_1 + 1.15x_2 + 0.78x_3 = 1{,}100 + d_3^+ - d_3^-$$

- For staff

$$\sum_{i=1}^{3} a_{i4}x_i = 1.50x_1 + 0.80x_2 + 0.93x_3 = 2{,}850 + d_4^+ - d_4^-$$

(ii) Manager goal equations:

- For necessities in Country 1

$$x_1 = 1{,}200 + d_5^+ - d_5^-$$

- For necessities in Country 2

$$x_2 = 1{,}200 + d_6^+ - d_6^-$$

- For necessities in Country 3

$$x_3 = 600 + d_7^+ - d_7^-$$

(iii) Achievement/objective function

$$\min D = \frac{0.20\,(0.5d_1^+ + 0.5d_1^-)}{5{,}400} + \frac{0.20\,(0.5d_2^+ + 0.5d_2^-)}{9{,}200} + \\ + \frac{0.15\,(0.5d_3^+ + 0.5d_3^-)}{1{,}100} + \frac{0.15\,(0.5d_4^+ + 0.5d_4^-)}{2{,}850} + \\ + 0.08d_5^- + 0.11d_6^- + 0.11d_7^-$$

where,

$x_i \geq 0$ is the number of managers to be trained by the company in the ith country.

Solving the model by LINGO, the following solution is founded:

$x_1 = 1{,}200$
$x_2 = 1{,}200$

$$x_3 = 600$$
$$d_1^+ = 426; \quad d_1^- = 0$$
$$d_2^+ = 426; \quad d_2^- = 2{,}486$$
$$d_3^+ = 1{,}852; \quad d_3^- = 0$$
$$d_4^+ = 468; \quad d_4^- = 0$$
$$d_5^+ = d_5^- = d_6^+ = d_6^- = d_7^+ = d_7^- = 0$$

According to this satisfying solution, necessities of training in every country are strictly covered as every target is reached. Concerning costs, the company spends even more than the targets in three goals: teaching in investment control, administration and staff. However, the target for the second goal, which is very high (9,200 weekly) is recommended to be cut.

5.3 Risk Aversion and Statistical Risk

In investment analysis, both risk aversion and statistical risk influence the investor choice. To clearly define these concepts and discern between them is important. Risk aversion means a psychological attitude manifested by each particular individual concerning investments. From their particular psychology, culture, needs, wealth, fears and motivations some investors are willing to take risks while others are not. They are called risk seekers and risk averters, respectively. Risk neutrality means a psychological attitude between risk aversion and risk seeking. Another usual term is risk tolerance, which is the opposite attitude to risk aversion. In contrast, statistical risk is the result of measuring risk in a scientific way by predicting events in terms of probability or even in terms of likelihood. Statistical risk is a datum to help investors make their own decisions. To sum up, risk aversion is the subjective side of risk perception while statistical risk is the objective side.

5.3.1 Risk Aversion as Depending on the Investor's Utility

Imagine an investor who should choose one of the following mutually exclusive alternatives:

(i) To invest in business B_1 whose monthly returns range (–0.05 to 1.50) with mean value of 0.97.
(ii) To invest in business B_2 whose monthly returns range (0.15–0.20) with mean value of 0.17.

A risk seeker will probably choose business B_1 while a risk averter will be inclined to choose business B_2.

Table 5.1 Utility function of family F

Wealth (W million dollars)	3	6	9	12	15
First order finite difference (ΔW)	–	3	3	3	3
Second order finite difference ($\Delta^2 W$)	–	–	0	0	0
Utility (U index)	100	180	234	270	270
First order finite difference (ΔU)	–	80	54	36	0
Second order finite difference ($\Delta^2 U$)	–	–	−26	−18	−6

Arrow (1965) risk theory, which relies on utility theory under uncertainty, assumes that risk aversion is determined by the investor's utility depending on the investor's wealth. Arrow's theory leads to normative rules of investing which are widely accepted by economists and financial analyst although widely rejected by psychologists and sociologists who prefer an exact detailed description of facts. Indeed, Arrow's risk aversion involves a simplification of facts but this kind of simplifications has proven fertile in science for centuries. Let us highlight the Arrow's seminal idea. To earn a few dollars more may be vital for poor people but if you gives a few dollar tip to a wealthy person, he or she will reject this present and would be offended. This is because poor people's utility substantially increases with one additional dollar while wealthy people's utility does not increase at all.

In Table 5.1, the relationship between wealth W and utility U for a certain family F leaving in a developed country is illustrated. Wealth means capital assets and human capital (education, entrepreneurial ability, social status and business opportunities). The family wealth generates an annual flow of family income; thus, for example, 3 million dollars wealth might generate yearly income of $50,000.

- If W was 3 million dollars, this wealth would allow family F to sufficiently cover their necessities, although some expenses in goods and services should be somewhat limited. Utility is indexed at level 100.
- If W was 6 million dollars, family F would enjoy a high standard of live. Utility increases to 180 units ($\Delta U = 80$).
- If W was 9 million dollars, family F would enjoy a very standard of live. Utility increases to 234 units ($\Delta U = 54$).
- If W was 12 million dollars, family F would reach an opulent lifestyle, namely, the highest feasible standard of life would be attained. Utility increases to 270 units ($\Delta U = 36$).
- If W was 15 million dollars, this exorbitant wealth would not add welfare to Family F as the highest feasible standard of life has been already reached with 12 million dollars wealth. Zero increase in Utility ($\Delta U = 0$).

For most families, happiness of increasing wealth is less impressive than regret of losing wealth, quantities involved another things being equal. More precisely, marginal utility ΔU provided by one additional money unit of wealth is less than marginal disutility of losing one money unit of wealth (see Table 5.1). In Fig. 5.1, utility of family F is represented. According to Table 5.1, the utility curve (which

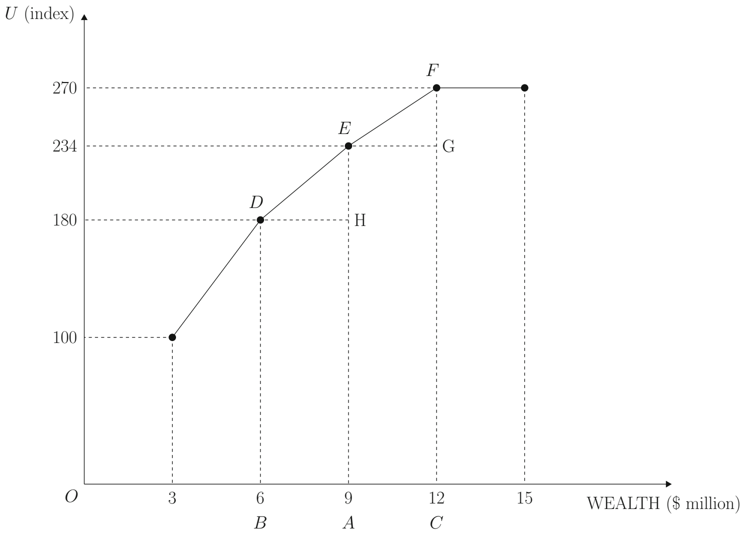

Fig. 5.1 Utility curve of family F

has been plotted as a polygonal line) monotonously growths with decreasing slopes as wealth growths.

In Fig. 5.1, suppose that family F has 9 million dollars wealth. Suppose also that this level OA of wealth can randomly increase to OC or decrease to OB, both events with equal probability. We have:

$$\Delta W^{+} = AC = 3 \quad \text{if the event is positive}$$

$$\Delta U^{+} = HF = 36 \quad \text{if the event is positive}$$

$$|\Delta W^{-}| = BA = 3 \quad \text{if the event is negative}$$

$$|\Delta U^{-}| = GE = 54 \quad \text{if the event is negative}$$

$$\Delta^2 U = \Delta U^{+} - |\Delta U^{-}| = HF - GE = -18$$

Family F is concerned with the negative $\Delta^2 U$ value as this result means that expected losses in utility exceed expected increments. This concern means risk aversion. Therefore, a suitable measure $r_A(W)$ of risk aversion is $\left|\Delta^2 U\right|$ normalized by ΔU, namely:

$$r_A(W) = \frac{\left|\Delta^2 U\right|}{(\Delta U^{+} + |\Delta U^{-}|)} = \frac{(-1)\Delta^2 U}{(\Delta U^{+} + |\Delta U^{-}|)} \tag{5.9}$$

From the scale of wealth given in Table 5.1, Eq. (5.9) yields:

$r_A(W) = 26/54 = 0.48$ for $W = 9$
$r_A(W) = 18/36 = 0.5$ for $W = 12$

In infinitesimal calculus, the first and second finite differences become the first and second derivatives $U'(W)$ and $U''(W)$, respectively. Then, Eq. (5.9) becomes:

$$r_A(W) = \frac{(-1)U''(W)}{U'(W)} \tag{5.10}$$

which is called Arrow's absolute risk aversion (ARA) coefficient. From Eq. (5.10), Arrow's relative risk aversion is defined as follows:

$$r_R(W) = r_A(W)W \tag{5.11}$$

Some analysts use the concept of risk tolerance, which is the inverse of risk aversion, but the value added by this related concept to theory and practice seems rather irrelevant.

As noted, although most people are risk averters, some investors are either risk seekers or risk neutral investors. For a risk seeker (also called risk lover), to lose one additional money unit has less importance (in terms of utility) than the fact of increasing one additional money unit wealth. Accordingly, risk seekers practice active management in the Exchange market through risky trading operations. Risk neutral investors have psychological profiles between risk seekers and risk averters.

5.3.2 *Eliciting ARA in Arrow's Utility Scenarios*

To discuss mathematical forms of utility and elicit ARA coefficients, several alternative assumptions should be here considered. One of these statements assumes decreasing risk aversion as the levels of wealth growth. Conversely, the other statement assumes increasing risk aversion. Perhaps, non of these general rules are sufficiently realistic.

A stream of financial analysts think that risk aversion for the poorest is higher than for the wealthiest. On this assumption of ARA decreasing performance, Copeland and Weston (1988, p. 89) say: "The Pratt-Arrow definition of risk aversion is useful because it provides much more insight into people 's behavior in the face of risk. For example, how does ARA change with one 's wealth level? Casual empiricism tells us that ARA will probably decrease as our wealth increases. A \$1000 gamble may seem trivial to a billionaire, but a pauper would probably be very risk averse toward it".

A usual utility function capable of reflecting ARA decreasing performance is power utility, namely:

$$U = aW^b; \quad 0 > b > 1; \quad a > 0 \tag{5.12}$$

In Table 5.1, the scale of wealth and utility levels reaches a satiation point from which utility stop growing. Power utility is unable of reflecting satiation points since utility in Eq. (5.12) monotonously growths with the level of wealth ($U \to \infty$ for $W \to \infty$).

From Eqs. (5.10) and (5.12), ARA coefficient r_A is obtained:

$$r_A = \frac{(1-b)}{W} \tag{5.13}$$

In Eq. (5.13), r_A monotonously decreases with W, but the extreme value $r_A = 0$ is never attained at feasible W levels.

To elicit the ARA coefficient from a scale of W and U levels like the scale in Table 5.1, Eq. (5.12) is written as follows:

$$\log U = \log a + b \log W \tag{5.14}$$

Regression analysis on Eq. (5.14) allows the analyst to estimate parameter b, which is then introduced into Eq. (5.13) to obtain the r_A coefficient.

Systematic test to accept or reject the hypothesis of ARA decreasing performance are difficult to implement in broad representative scenarios. Without testing support, conjectures on ARA behaviour are problematic. Hints on this issue are pointing in opposite directions. Some risk seekers involved in trading activity are wealthy while other are not. Many gamblers are people of limited income. Old rich businessmen maintain habits of strong risk aversion, while less rich young businessmen invest in joint venture projects to get, if lucky, capital they need at the beginning of the career.

5.4 Risk Aversion for Portfolio Random Returns: How to Elicit ARA Coefficients

As we have just seen, risk aversion is explained in terms of wealth from classic utility theory under uncertainty. In other contexts, however, risk aversion should be explained in terms of return of investments. This is the case of portfolio selection and management. In the Modern Portfolio Theory (MPT) framework, the critical variable determining risk aversion is not wealth but return. A risk averse investor is concerned with possible random changes in the portfolio returns while a risk seeker is not.

Consider a risk averter H faced with a given investment of random return R. Probabilities objectively measured are unknown or they are ignored by the investor.

To elicit a proxy for the ARA coefficient, a dialogue between the analyst and the investor is further conducted. Questions and answers are, for example, as follows.

Analyst. Please, consider two potential events concerning your investment. One of them is to receive return of 1.1 % on the investment, while the other is to receive 0.9 % return. Which is the most probable outcome to your eyes?
Risk averse investor. 0.9, I am afraid.
Analyst. Which likelihood, namely, subjective probability do you assign to event 0.9?
Risk averse investor. About 80 %.

From this dialogue, the investor's likelihoods are 0.8 and 0.2 respectively.

This example of dialogue suggest the following general statement. Suppose the investor has received R_t return in period t. Suppose also that this return can randomly change by increasing either up to $R_{t+1} = R_t + \Delta R_t$ or by decreasing up to $R_{t+1} = R_t - \Delta R_t$ in period $t + 1$. Let L^* and L^- be the investor's likelihoods for these events, respectively. We assume:

$$\left.\begin{array}{ll} L^+ < L^- & \text{if the investor is a risk averter} \\ L^+ = L^- & \text{if the investor is a risk neutral} \\ L^+ > L^- & \text{if the investor is a risk seeker} \end{array}\right\} \tag{5.15}$$

Assumption (5.15) says that risk averters are willing to set L^- higher than L^+. In fact, risk averters are very much concerned with low returns, and because of this fear they imagine that $(R_t - \Delta R_t)$ is a more probable return than $(R_t + \Delta R_t)$. Psychologist can explain why the cowards imagine that threats will always occur. In contrast, risk seekers who do not fear to receive low returns, prefer to think that the best will occur, and therefore, they assign L^- lower than L^+.

Now, in the risk aversion case, we define investor's subjective expected return as the return on the investment that the investor expects to receive in terms of likelihood. We have:

$$E_S(R_t + \Delta R_t) = R_t + \Delta E_S^+ = R_t + L^+ \Delta R_t \tag{5.16}$$

$$E_S(R_t - \Delta R_t) = R_t - |\Delta E_S^-| = R_t - L^- \Delta R_t \tag{5.17}$$

where ΔE_S^+ and ΔE_S^- are first order finite differences of E_S.

$$\Delta^2 E_S = \Delta E_S^+ - |\Delta E_S^-| \tag{5.18}$$

where $\Delta^2 E_S$ is a second order finite difference.

By comparing these variables to the previously defined variables in Sect. 5.3, we have the following formal correspondences:

$$\Delta E_S^+ \leftrightarrow \Delta U^+$$
$$|\Delta E_S^-| \leftrightarrow |\Delta U^-|$$
$$\Delta^2 E_S \leftrightarrow \Delta^2 U$$
$$\frac{\left|\Delta^2 E_S\right|}{\Delta E_S^+ - \left|\Delta E_S^-\right|} \leftrightarrow \frac{\left|\Delta^2 U\right|}{\Delta U^+ - |\Delta U^-|}$$

where the right-hand side of the later formal correspondence is ARA coefficient $r_A(W)$ given by Eq. (5.9). This justifies the following definition of ARA coefficient $r_A(R)$ for returns.

$$r_A(R) = \frac{\left|\Delta^2 E_S\right|}{\Delta E_S^+ - \left|\Delta E_S^-\right|} = \frac{(-1)(\Delta E_S^+ - \left|\Delta E_S^-\right|)}{(\Delta E_S^+ + \left|\Delta E_S^-\right|)} = \frac{(L^- - L^+)}{L^+ + L^-} = L^- - L^+ \tag{5.19}$$

According to Eqs. (5.15)–(5.17). Equation (5.19) allows the analyst easily elicit by an interactive dialogue with the risk averse investor like the dialogue at the beginning of this section. Concerning our numerical example, we obtain:

$$r_A(W) = 0.8 - 0.2 = 0.6$$

From Eq. (5.19), ARA coefficient $R_A(R)$ ranges between 0 and 1. The lower bound corresponds to $L^- = L^+$, which means risk neutrality. The upper bound corresponds to $L^- = 1$ and $L^+ = 0$, which means extreme risk aversion.

5.4.1 Mean-Variance Stochastic Goal Programming (MV-SGP) Model

To select stock portfolios from the principles of Modern Portfolio Theory (MPT), we here extend Markowitz's mean value-variance (E-V) model (Markowitz 1952) to the multicriteria case in which the investor is faced with optimizing utility received from different sources or scenarios. Before rushing into this purpose, the Markowitz model will be briefly reviewed.

5.4.2 Markowitz E-V Model

This assumes maximizing expected utility to be received from a single source/scenario of returns, namely, the so called Eu(R). A standard way of formulating the model is as follows:

$$\min V_p(x_1, x_2, \ldots, x_j, \ldots, x_m) \tag{5.20}$$

subject to

$$E_p = \sum_{i=1}^{m} e_i x_i = E_0 \tag{5.21}$$

$$\sum_{i=1}^{m} x_i = 1 \tag{5.22}$$

with the non negativity conditions, where:

$(x_1, x_2, \ldots, x_j, \ldots, x_m)$ = vector of portfolio weights
$V_P(x_1, x_2, \ldots, x_j, \ldots, x_m)$ = portfolio variance, which is a quadratic function of the portfolio weights.
E_0 = investor's target for the portfolio expected return. This target can be moved parametrically.

By solving model (5.20)–(5.22), an efficient frontier of the E-V criteria is obtained.

5.4.3 A Multiobjective Extension: The MV-SGP Model

In this extension of the Markowitz's model, we will connect WGP with Arrow-Pratt investment paradigm. Consider an investor facing with random returns R_j on a portfolio from different sources/scenarios $j = 1, 2, \ldots n$. This is equivalent to say that there are n objectives or goals. Then, we write:

$$R_j = \sum_{i=1}^{m} r_{ij} x_i \quad j = 1, 2, \ldots, n \tag{5.23}$$

together with the budget constraint (sum of portfolio weights equal to 1), namely,

$$\sum_{i=1}^{m} x_i = 1 \tag{5.24}$$

where,

x_i is the ith portfolio weight (percentage of capital to be invested in the ith component of portfolio P).

r_{ij} is random return on the ith component of portfolio P, this return being related to the jth goal.

By applying the $Eu(R)$ maximization principle to multiple returns R_j given by Eq. (5.23), we have the following multiple objective programming model:

$$\max Eu\left(\sum_{i=1}^{m} r_{ij}x_i\right); \quad j = 1, 2 \ldots n \tag{5.25}$$

subject to budget constraint (5.24) and the non-negativity conditions.

Problem (5.25) is extremely difficult to solve, so that we should use a satisfying proxy for this problem in the bounded rationality framework. Difficulties inherent in this task are as follows. As Arrow (1965, p.94) states, most investors are risk averters, which involves a non-linear utility function with first derivative $u'(R) > 0$ (because utility increases as return increases) and second derivative $u''(R) < 0$ (because utility growth does not move proportionally, namely, marginal utility u' decreases as R increases). Forms and parameters of the utility function are generally unknown. Eliciting the utility parameters would require extremely cumbersome research for each particular investor, so that the analyst could hardly specify the utility function in practice. This problem cannot be simplified by introducing a linear utility function. Indeed, utility is not linear for risk averse investors, but it is linear in the special infrequent case of risk neutrality only. Because of these difficulties, a satisfying proxy for problem (5.25) should be used. A proxy for this purpose is EV-Stochastic Goal Programming (EV-SGP, Ballestero 2001), whose meaning and justification are as follows.

Consider Pratt (1964) approximation, namely:

$$\left[Eu\left(R_j\right)\right]^N = \left[u(ER_j)\right]^N - \frac{1}{2}A_j\sigma^2(R_j) + o_j \tag{5.26}$$

where,

superscript N denotes that each square bracket is normalized by the first derivative $u'(R_j)$ specified at the mean value of R_j, according to Arrow's normalization.

$\sigma^2(R_j)$ is the jth portfolio variance (square of standard deviation).

o_j is a small remainder, which can be neglected according to Pratt's approximation.

A_j is Arrow's absolute risk aversion (ARA) coefficient for the jth goal.

From Eq. (5.26) we have that expected utility of returns (left hand side of the equation) is less than (or equal to) utility of expected return $u(ER_j)$, both after Arrow's normalization. Then, expression (5.26) is viewed by EV-SGP as a goal programming equation system with positive deviations and negative deviations d given by:

$$d_j^- = A_j \sigma^2(R_j) \tag{5.27}$$

From Eq. (5.27) the weighted goal programming achievement function becomes:

$$\min \sum_{j=1}^{n} \alpha_j A_j \sigma^2(R_j) \tag{5.28}$$

In Ballestero (2001), this previous insight is strictly addressed leading to the following parametric quadratic programming model:

$$\min v = XVX^T \tag{5.29}$$

subject to

$$\sum_{i=1}^{m} (Er_{ij} x_i) x_i \geq t_j; \quad j = 1, 2 \ldots n \tag{5.30}$$

$$\sum_{i=1}^{m} x_i = 1 \tag{5.31}$$

together with the non-negativity conditions. In Eq. (5.30), the term Er_{ij} is the expected return of random variable r_{ij} previously defined. In Eq. (5.29) we have:

$$V = \sum_{j=1}^{n} \alpha_j A_j V_j$$

where:

α_j is the investor's preference weight for the jth goal.
A_j is the investor's risk aversion for the jth goal.
V_j is the covariance matrix of returns r_{ij} in the jth scenario.

Other symbols in the model are as follows:

$X = (x_1, \ldots x_i, \ldots x_m)$ is the row vector of decision variables (portfolio weights);
X^T is the transposed vector of X.
t_j is the jth target or aspiration level established by the investor for the jth goal.

In minimization (5.29), notice that objective value v is a composite measure of portfolio variances XV_jX^T $(j = 1, 2, \ldots n)$. This objective value is called portfolio variability.

Model (5.29)–(5.31) is straightforwardly solved by MatLab or by Lingo special GenPRT.lg4 software, thus obtaining portfolio solutions depending on the targets.

5.4.4 Two Objective Case

In applications, the special case of two objectives often appears. For example, to select portfolios from two sources of information or two different perspectives as is shown hereafter:

(i) Time series of returns over the last 5 years versus time series of returns over the last year (more recent year).
(ii) Time series of returns over the last 5 years versus investor's conjectures on returns in the near future.
(iii) E-V model versus a mean-semivariance model.
(iv) E-V model without an investor's target versus E-V model with an investor's target.
(v) E-V model without veto versus E-V model with veto.
(vi) A purely financial goal versus a mixed SRI financial goal.

In the two objective case, model (5.29)–(5.31) becomes:

$$\min(\alpha_1 A_1 V_1 + \alpha_2 A_2 V_2) = \min(\alpha_1 q V_1 + \alpha_2 V_2); \quad q = \frac{A_1}{A_2} \tag{5.32}$$

subject to

$$\sum_{i=1}^{m} (Er_{i1} x_i) x_i \geq t_1; \tag{5.33}$$

$$\sum_{i=1}^{m} (Er_{i2} x_i) x_i \geq t_2; \tag{5.34}$$

together with the non-negativity conditions.

5.5 Selecting SRI-Financial Portfolios: Stages in the Process

To select stock portfolios from a purely financial perspective requires performing two stages as follows. First stage, to define the opportunity set of stocks. Second stage, to determine the portfolio composition from the stocks included in the opportunity set. There are analytic models and sophisticated techniques to undertake the second stage but so far similar models and techniques are not use concerning the first stage. Large opportunity sets such as SP500 and Footsie are often preferred by decision makers with or without justifying the choice from particular conveniences, while small opportunity sets (e.g., Down Jones) are preferred in other context. Anyway, these are a priori choices without a methodological support.

Consider now the problem of selecting stock portfolios from a SRI-financial perspective. This means that the investor has ethical goals and financial goals, which should be combined in a bi-objective stochastic model to determine the portfolio. Stages in this process are stated as follows.

First stage. An opportunity set of stocks is chosen on a provisional basis, as this set will be further modified taking SRI criteria into account. In fact, each stock in the provisional set is analysed by checking whether or not it meets ethical requirements sufficiently. Those stocks rejected by this test are removed from the opportunity set. For this purpose, the following two types of screening are used (Knoll 2002).

(i) Negative screening (NS) is the oldest and most basic SRI filter. If a company is not involved in businesses that are detrimental to a given ethical issue (EI). For example, the company is not a tobacco manufacturer or dealer. Then, the respective asset gets one NS concerning this EI issue.
(ii) Positive screening (PS) refers to a company that pursues policies in favor of a given ethical issue (EI). For example, policies against air and water pollution. Then the respective asset gets one PS concerning this EI issue.

To have a relatively high number of NS and PS is only a good recommendation to be included in the final opportunity set. In other words, it is a necessary but not sufficient condition. Other conditions such as transparency and credibility of the company should also be considered (see, Chap. 4).

Second stage. From the screened opportunity sets of stocks, the decision makers (investors or fund managers) select their SRI financial portfolios with the help of analytic or empirical tools according with their experience and expertise. In Chaps. 6 and 7 we use MV-SGP model for this purpose.

Conclusions

We have reviewed the analytic framework on which Markowitz mean-variance model derives. We have shown that MV-SGP generalises Markowitz M-V, which has two objectives (profitability and risk), to multiple objectives, which can be either financial, SRI or others. In our context, MV-SGP with SRI objectives has been of principal interest. Ethical portfolio selection is a process including two stages. First, to screen the opportunity set of stocks by using a SRI synthetic indicator. In this stage, those assets which do not reach

(continued)

a significant ethical level are removed. Second, to select the stock portfolio from the screened opportunity set by MV-SGP with financial and SRI goals. In later chapters, the second stage will be developed.

A value added by this chapter to methodology refers to the problem of eliciting the investor's ARA coefficient for random returns. In Sect. 5.4, a procedure to help solve this problem has been proposed, which relies on formal correspondences between the utility framework and the subjective expected return framework.

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Chapter 6
Selecting SRI Financial Portfolios Applying MV-SGP Model

Enrique Ballestero and Ana Garcia-Bernabeu

Abstract In this chapter, the second stage to stock portfolio selection combining ethical and financial objectives is described. For this purpose, MV-SGP model is used. As a prior question, the financial and ethical goals under uncertainty are formulated. Once the goals are specified, the statement of MV-SGP requires defining financial and SRI targets. A significant question is how to estimate Arrow's absolute risk aversion (ARA) coefficients. This question is examined in detail. The ARA coefficients are critical parameters to state the achievement function in MV-SGP model, while preference weights for the goals are not considered. This is because SRI preferences widely differ from an investor to another. Only in the case that portfolio selection is addressed to one given investor, his/her preferences are introduced into the achievement function

6.1 Goal Statement Under Uncertainty from Financial and SRI Perspectives

The Mean-Variance Stochastic Goal Programming (MV-SGP) is a method capable of providing "satisficing" solutions in the uncertainty case from the standard expected utility perspective (Ballestero 2001). To formulate financial and ethical goals under uncertainty we start with an opportunity set S of m assets, which is split as follows:

(a) A subset S^* of h ethical assets, which are characterized by ethical and financial criteria;
(b) A subset S^{**} of the $(m - h)$ remaining assets, which are characterized by financial criteria only.

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Notation is F_i $(i = 1, 2, \ldots h)$ for subset S^* and $F_i (i = h+1, h+2, \ldots m)$ for subset S^{**}.

The choice of SRI portfolios relies on classical normative $Eu(\tilde{R})$ utility theory under uncertainty (Von Neumann and Morgenstern 1947; Arrow 1965) and a huge range of literature. As well-known, $\tilde{R}$ denotes random returns while $Eu(\tilde{R})$ is expected utility of these returns. According to this classical theory, the higher the expected utility the better the investment.

Goal 1 is defined as follows:

$$\begin{aligned} & Eu_1(\tilde{R}_1) \to u_1(\bar{R}_1) \\ & \bar{R}_1 \geq g_0 \\ & \tilde{R}_1 = \sum_{i=1}^{m} \hat{f}_i x_i \\ & \sum_{i=1}^{m} x_i = 1 \end{aligned} \tag{6.1}$$

Goal 2 is defined as follows:

$$\begin{aligned} & Eu_2(\tilde{R}_2) \to u_2(\bar{R}_2) \\ & \bar{R}_2 \geq e_0 \\ & \tilde{R}_2 = \sum_{i=1}^{h} \hat{f}_i x_i + \sum_{i=h+1}^{m} \hat{\varphi}_i f_i x_i \\ & \sum_{i=1}^{m} x_i = 1 \end{aligned} \tag{6.2}$$

with the non-negativity conditions $x_i \geq 0$ for all i, where:

u_1 and u_2 are investor's utility from goals 1 and 2, respectively.
Eu_1 and Eu_2 are expected utility for u_1 and u_2, respectively.
$\hat{R}_1$ and $\hat{R}_2$ are random returns on each portfolio.
$\bar{R}_1$ and $\bar{R}_1$ are expected returns.
g_0 and e_0 are investor's targets or aspiration levels.
$\hat{f}_i$ is weekly random return on the ith asset.
$\hat{\varphi}_i$ is assumed to be equal to zero for $i = h+1, h+2, \ldots m$ (see justification below).
x_i is the ith portfolio weight. They are decision variables.

Symbol $\rightarrow$ means that expected utility (left hand side of each equation) should approximate its respective upper limit (right hand side) as close as possible.

Let us highlight the meaning of each goal. In our context, the investor's profile is quite different from the traditional profile. Traditionally, most investors are merely interested in expected returns and risk, namely, their primary objective is financial security and income, no matter SRI. Any ethical objective falls outside the scope of these traditional investors. Conversely, the ethical investor looks for a compromise between two goals as follows.

Goal 1 It reflects the purely financial side of the question, and does not require special explanation. It is a classic issue in financial analysis, namely, the $Eu(\tilde{R})$ objective of traditional investors, who consider series of historical returns in the recent past as the best guidance to invest.

Goal 2 It reflects the SRI side. It is the $Eu(\tilde{R})$ objective of a "quaker" (extremely ethical) investor – as well known, the Religious Society of Friends or quakers movement advised their members to invest from social criteria, as they believed in fairness and peaceful purposes. To mathematically formulate the fact that the "quaker" will never invest in the S^{**} assets, we make $\hat{\varphi}_i = 0$ $(i = h+1, h+2, \ldots, m)$ in Eq. (6.2), namely, every random return is replaced by a fictitious return equal to zero. This means that assets F_i $(i = h+1, h+2, \ldots, m)$ have no value for the "quaker". Mathematically, this based statement is more convenient than the alternative statement of removing the "non-ethical" set $(h+1, h+2, \ldots, m)$ from goal 2. In fact, the based statement allows us to define both goals in a similar way, which leads to more elegant and easier mathematical developments.

Therefore, the ethical investor in this paper is neither a traditional nor a "quaker" investor, but a decision maker who seeks a satisfying solution from two conflicting goals.

6.2 Analytic Statement for the Financial-Ethical Bicriteria Model

System (6.1)–(6.2) is proven to have a deterministic equivalent given by the following mean variance-stochastic goal programming (Ballestero 2001, 2005) parametric quadratic programming model.

$$\min XV^T X \tag{6.3}$$

where:

X is the row vector $(x_1, x_2, \ldots, x_m)$.
X^T is the transposed vector of X.

V is a $m \times m$ matrix, which will be defined below (this matrix summarizes variability of returns).

Minimization (6.3) is subject to the following goal equations:

$$\bar{R}_1 = \sum_{i=1}^{m} \bar{f}_i x_i \geq g_0 \tag{6.4}$$

$$\bar{R}_2 = \sum_{i=1}^{m} \bar{f}_i x_i \geq e_0 \tag{6.5}$$

where $\bar{f}_i$ is expected return on the ith asset. In addition, the portfolio weight constraint which restricts the sum of the portfolio weights to be 1 is imposed, namely:

$$\sum_{i=1}^{m} x_i = 1 \tag{6.6}$$

together with the non-negativity conditions.

As proven in EV-SGP, matrix V is stated as follows:

$$V = r_1 V_1 + r_2 V_2 \tag{6.7}$$

where r_1 and r_2 are the Arrow's absolute risk aversion (ARA) coefficients for each goal, while V_1 and V_2 are covariance matrices expressing variability of returns for goal 1 and 2, respectively.

Using weights for normalization purposes is not required, as the variables in our model are normalized.

6.3 Model Targets

First, we define the ethical (SRI) target as follows:

$$e_0 = \lambda \bar{f}_{emax} \tag{6.8}$$

where $\bar{f}_{emax} = max \bar{f}_i \quad (i = 1, 2, \ldots, h)$ while parameter λ (ranging between 0 and 1) increases as the investor's aspiration level for the ethical goal increases.

As usual in E-V models, target g_0 is treated as a parameter moving on a feasible interval.

A discussion on this matter is as follows.

Suppose first that the above maximum expected return, namely, the mean value in Eq. (6.8) is positive.

Case 1 Suppose $\lambda > 1$. Then, no feasible solution to model (6.3)–(6.7) can be found.

Case 2 Suppose $\lambda = 1$. Then, there is only one solution, namely,

- $x_i = 1$ if $i = p$ where p is the ethical asset of maximum expected return in Eq. (6.8);
- $x_i = 0$ if $i \neq p$.

This non-diversified solution corresponds to a "quaker" investor who maximizes the expected return.

Case 3 Suppose $0 \leq \lambda \leq 1$. Then, the higher the λ value the higher the e_0 ethical target. Consider a value $\lambda = \lambda_0$. This leads to solutions such as the following ones:

$$\sum_{i=1}^{h} x_i = q \geq \lambda_0; \quad q \leq 1;$$

$$\sum_{i=1}^{h} x_i = 1 - q;$$

Consider $\lambda = 0.75$. From the above discussion, this λ value might yield a q value close to 0.75 so that $(1 - q)$ might reach levels close to 0.25. Then, $\lambda = 0.75$ does not generally correspond to a "quaker" investor, although it can correspond to a strongly ethical investor.

Case 4 Suppose $\lambda < 0$. Then, target e_0 given by Eq. (6.8) would be less than zero, which has little sense because even the "quaker" investors do not like negative expected returns.

Now, suppose that maximum expected return in Eq. (6.8) is negative. Then, to invest in ethical assets is not advisable, as the "quaker" investors are not satisfied with negative expected returns either.

6.4 Estimating ARA Coefficients

As well-known, risk aversion does not mean risk at all. It is a psychological concept describing the investor's psychological attitude towards risk – this attitude may or may not be influenced by a risk perception. Many investors behave as risk averse, namely, they prefer portfolios of low volatility, other things being equal. Other investors are risk neutral, while a few are risk lovers. To estimate the ARA coefficients and in our context, two approaches can be alternatively used as follows.

(i) **First approach** Coefficients r_1 and r_2 are straightforwardly elicited by comparing the investor's attitude towards risk in a framework unrelated to Arrow's risk aversion theory. An advantage of this approach is simplicity; however, there is a major drawback that ignores Arrow's risk aversion equation – see below.

(ii) **Second approach** Comparison of r_1 to r_2 is made in the framework of Arrow's theory. Let us consider the following two scenarios.

Scenario 1 Several investors with different wealth face a given investment, which is the same for all of them. In this scenario, which is outside this chapter, the jth ARA coefficient depends on the jth investor's wealth W_j through Arrow's equation (Arrow 1965, p.94):

$$r_j = (-1)u_j^{''}(W_j)/u_j^{'}(W_j); \quad W_j \geq 0$$

where first derivative $u_j^{'} > 0$ and second derivative $u_j^{''} < 0$. In the case of risk neutrality, $u_j^{''} = 0$ so that $r_j = 0$. Financial authors assume that r_j decreases with the increase of the investor's wealth (Copeland and Weston 1988, p.89).

Scenario 2 A single investor faces several investments or goals. This is the true scenario in this chapter. Then, Arrow's equation turns into:

$$r_j = (-1)u_j^{''}(R_j)/u_j^{'}(R_j); \quad R_j \geq 0 \tag{6.9}$$

For ease of notation, we here write R_j instead of $\tilde{R}_j$ to denote random return. In this case, $j = 1, 2$ for goals 1, 2, respectively. Both derivatives are specified by making return $R_j = \bar{R}_j$. Here, r_j increases with the increase of the $\bar{R}_j$ expected return, other things being equal.

To justify this property, let us consider an investor whose wealth amounts to \$50,000, and an investment H whose returns might be as follows. Case (a). Random returns on H are \$10,000 and \$30,000 with equal probability, so that $\bar{R}_H = 20{,}000$. If so, the investor would perceive high risk in comparing return variability to wealth. Case (b). Random returns on H are \$1 and \$3 with equal probability, so that $\bar{R}_H = 2$. If so, the investor would perceive no risk in comparing return variability to wealth.

Therefore, if the investor's risk aversion is influenced by his/her perception of risk, then ARA in case (a) is higher than ARA in case (b), other things being equal. Thus, the before mentioned property is justified. Notice that both cases (a) and (b) lead to the same risk level $(\sigma H/\bar{R}_H)$ as measured by the coefficient of variation.

Quadratic utility is the only usual utility form that satisfies the previous mentioned property (Kallberg and Ziemba 1983). Therefore, for the limited purpose of eliciting the ARA coefficients and only for this purpose, we will here use quadratic utility as a laboratory tool, namely:

$$\begin{aligned} u_j &= 2b_j R_j - c_j R_j^2 \\ b_j, c_j &> 0; \quad j = 1, 2 \end{aligned} \tag{6.10}$$

Equations (6.9)–(6.10) yield:

$$r_j = \frac{1}{(b_j/c_j) - \bar{R}_j}; \quad j = 1, 2 \tag{6.11}$$

By maximising utility (6.10) we have:

$$b_j - c_j R_j = 0 \Rightarrow R_j^* = b_j/c_j \tag{6.12}$$

where is the return that maximises function (6.10). From Eqs. (6.11) and (6.12) we get:

$$r_j = \frac{1}{(R_j^*) - \bar{R}_j}; \quad j = 1, 2 \tag{6.13}$$

Remark 1 Notice that R_1^* is much greater than $\bar{R}_1$. This is because Eq. (6.12) gives us the so-called satiation point of the traditional investor ($j = 1$), namely, a return so high that more return does not increase the investor's utility. From Eqs. (6.4) and (6.5), we have $\bar{R}_1 \geq \bar{R}_2$ so that R_1^* is also much greater than R_2^*. Hence, ratios $\bar{R}_1/R_1^*$ and $\bar{R}_2/R_2^*$ are close to zero.

To elicit the ARA coefficients, the analyst should conduct a test through which the investor discloses his/her risk aversion for each goal. It is developed as follows.

(i) *Test input* Concerning goal 1, the test starts with a fictitious investment H_1 from an opportunity set, which is not characterized as an ethical set of assets. Investment H_1 has zero mean value and σ standard deviation. Concerning goal 2, the test requires considering a fictitious investment H_2 from ethical assets. Investment H_2 also has zero mean value and σ standard deviation of the observed returns. Therefore, H_1 and H_2 have equal volatility; however, the investor's risk aversion can differ from one another. From Eq. (6.13) we get:

$$r_{Hj} = \frac{1}{(R_j^* - \bar{R}_{Hj})} = \frac{1}{R_j^*}; \quad j = 1, 2 \tag{6.14}$$

where r_{Hj} is the ARA coefficient for each H_j fictitious investment since mean value $\bar{R}_{Hj}$ is equal to zero.

(ii) *Formulating the test* The analyst asks the investor: "If you really are an ethical investor, then your risk aversion for an ethical investment such as H_2 will be relatively low, namely, lower than your risk aversion for H_1, which has the same expected return and risk (volatility) as H_2 but it is not characterized as ethical. Taking this into account, would you like to compare your risk aversion for H_1 to your risk aversion for H_2?". Examples of answers are as follows.

- "My risk aversion for H_1 is significantly higher than for H_2, say, twice higher". Then, $r_{H2}/r_{H1} = 1/2$ on a scale of ARA ratios.
- "My risk aversion for H_1 is moderately higher than for H_2, say, 3/2 higher". Then, $r_{H2}/r_{H1} = 2/3$.
- "My risk aversion for H_1 is slightly higher than for H_2, say, 4/3 higher". Then, $r_{H2}/r_{H1} = 3/4$.

These answers have the following meaning. Suppose first that you are an extremely strong ethical investor. Then, you are willing to invest in ethical assets, even neglecting the undesirable consequences of risk on your utility. According to Arrow's theory, this means risk neutrality or almost risk neutrality, namely, you have zero or very low risk aversion for ethical investment. More precisely, a low ratio r_{H2}/r_{H1} together with a high ethical target, characterizes strongly ethical profiles of investor. In contrast, weakly ethical profiles appear when risk aversion for the ethical goal increases (namely, when the $r_{H2}/r_{H1} < 1$ is a ratio approaching 1) and the ethical target decreases. Cases in which, for example, both the r_{H2}/r_{H1} ratio and the ethical target reach high values are of doubtful characterization. Finally, suppose you are a traditional (non ethical) risk-averse investor. Then, you are willing to invest neither in ethical assets nor in other assets without previously considering the undesirable consequences of risk on your own utility. In this case, the appropriate portfolio selection approach is classical Markowitz's E-V model (Markowitz 1952).

(iii) *Test output* Once ratio has been specified on the above scale, Eq. (6.14) yields:

$$R_2^* = (r_{H1}/r_{H2})R_1^* \tag{6.15}$$

(iv) *ARA coefficients for goals 1 and 2*. From Eqs. (6.13) and (6.15), we have:

$$r_1 R_1^* = \frac{1}{1 - (\bar{R}_1/R_1^*)} \tag{6.16}$$

$$r_2 R_1^* = \frac{1}{(r_{H1}/r_{H2}) - (\bar{R}_2/R_2^*)} \tag{6.17}$$

From Eqs. (6.16) and (6.17) and Remark 1 we obtain:

$$r_1/r_2 \cong r_{H1}/r_{H2} \tag{6.18}$$

where ratio $r_{H1}/r_{H2} > 1$. Thus, the ARA coefficients are elicited in an approximate way.

6.5 Meaning of the Model in Terms of Risk and Risk Aversion

To highlight this meaning in terms of risk, notice that goals (1)–(2) lead to the following Pratt's (1964) relationship (Ballestero 2001):

$$\max\left[E_{uj}(\tilde{R}_j)\right]_{norm} \cong \left[u_j(\bar{R}_j)\right]_{norm} - (1/2)rj\sigma_j^2(\tilde{R}_j); \quad j = 1, 2 \tag{6.19}$$

where subscript "norm" means that the respective expression is normalized by the first derivative of utility u_j specified at the $\bar{R}_j$ mean value.

Moreover,

$\sigma_j^2(\tilde{R}_j) = X_j V_j X_j^T$ is the portfolio variance, which means risk for both goal $j = 1$ and the ethical goal $j = 2$.

X_j is the solution (vector of portfolio weights) to the following model:

$$\min X_j V_j X_j^T$$

subject to

$$\bar{R}_j \geq \begin{Bmatrix} g_0 & \text{if} & j = 1 \\ e_0 & \text{if} & j = 2 \end{Bmatrix}$$

together with the non-negativity conditions.

As the objective function (portfolio variance) is a measure of risk, goals (1) and (2) involve constrained risk minimization for the traditional (purely financial) investor and the "quaker" investor, respectively.

Now, consider the so-called ethical investor in this chapter, who is an investor between the traditional (purely financial) investor and the "quaker" investor. Here, vector X (portfolio weights) is the solution to model (6.3)–(6.7). Notice that the objective function, namely,

$$\min X(r_1V_1 + r_2V_2)X^T = r_1XV_1X^T + r_2XV_2X^T$$

is a composite index of variability instead of a portfolio variance. Then, how to measure the financial risk that the ethical (non traditional-non "quaker") investor bears? This risk is given by:

$$\text{var} \quad XV_1X^T$$

which is valid whatever the ethical characterization of the portfolio. In fact, matrix V_1 includes the covariances of all assets, whether the asset is ethical or not.

Therefore, matrix V_1 is a financial matrix while matrix V_2 does not describe financial risk. Obviously, we generally have:

$$X_j V_1 X^T \neq X_j V_j X_j^T \quad (j = 1)$$

because solution X is generally different from solutionX_j $j = 1$.

Finally, to highlight the meaning of the model in terms of risk aversion, consider the above Pratt's relationship focusing on its negative term on the right-hand side. The greater this negative term (in absolute value) the smaller the expected utility on the left-hand side, other things being equal, namely, if portfolio expected returns and the utility function are kept equal. This term is the product of two factors: (a) the portfolio variance, which is an observable risk measure; and (b) the r_j risk aversion coefficient, which describes the investor's perception of risk and his/her risk assessment from utility. The investor's expected utility suffers from the joint impact of both factors. For example, an individual with zero risk aversion for road accidents and high risk aversion for air accidents will prefer traveling by car despite being less comfortable and riskier than traveling by air. In the context of this chapter we can plausible assume that the strongly ethical investors have less risk aversion for ethical assets than the weakly ethical ones, other things being equal. Indeed, if one loves ethical investment, then one tends to close his eyes to the risk inherent in such investment.

As noted, defining goals (1)–(2) does not require assuming a special utility function. In contrast, the problem of eliciting risk aversion requires using a particular type of utility. In the previous section, the example for justifying elicitation by quadratic utility is valid whatever the ethical characterization of the investor. This is because even "quaker" investors are concerned about potential losses in their ethical investments.

Conclusions

As explained in the previous chapter, MV-SGP model provides "satisficing" solutions in the uncertainty case from the standard expected utility theory. From an opportunity set of assets, financial and ethical goals under uncertainty have been defined. In MV-SGP, the approach essentially consists in specifying the expected utility equation corresponding to each goal. The first goal reflects only the purely financial side of the target, while the second goal reflects the SRI side. Two approaches are developed to estimate ARA coefficients, which are critical parameters in the MV-SGP achievement function.

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Chapter 7
An Actual Case of SRI Financial Portfolio Choice by MV-SGP

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Abstract An illustrative example of ethical financial portfolio selection by MV-SGP model is developed through tables and numerical statements. Empirical data are real wide observations coming from international sources. This includes an opportunity set of 80 funds with historical series of weekly returns on the funds and SRI achievement indexes over 5 years time horizon. On this actual database, mean values vectors and covariance matrices are computed as a previous step required to formulate the objective function and constraints of the model. Since the computational structure of MV-SGP is the same as the computational structure of Markowitz-MV, the model is solved by using a Markowitz software application. The results are tabulated and discussed.

7.1 Introduction

Traditionally, many institutional or individual investors make their investment decisions only on the basis of financial criteria. However, since 1960, a financial behaviour known as Socially Responsible Investment (SRI) or ethical investment arises from the mid twentieth century including a political climate of social awareness for the environment, civil rights protection, distrust towards nuclear energy, and other concerns (Bauer et al. 2005). At the beginning of the twenty-first century this attitude has led to a strengthening of ethical management in some mutual funds, which invest in companies with powerful environmental policies,

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honest practices and social guidelines inspired by moral institutions. At the same time, support for ethical investing has remarkably increased.

No SRI portfolio selection model based on $E_u(R)$ has been found in previous papers. A proposal on managing SRI portfolios from a multicriteria standpoint is Hallerbach et al. (2004), but it is a linear approach. Conversely, there is a range of literature on portfolio selection with classical criteria (risk-return) and other criteria, but they are unrelated to the SRI problem. Concerning papers on multicriteria decision approaches to portfolio choice and related methods (from 2000 onwards), we can cite the following issues.

(i) Portfolio choice with fuzzy information (Arenas Parra et al. 2001; Perez-Gladish et al. 2007; Ballestero et al. 2009).
(ii) Approximating the optimum portfolio on the mean-variance efficient frontier by linkages between utility theory and compromise programming (Ballestero and Pla-Santamaria 2003, 2004, 2005).
(iii) Extending the classical (risk-return) approach to other different criteria (Steuer et al. 2007).
(iv) Novel approaches from multi-objective programming (Steuer et al. 2005).
(v) Constructing equity mutual funds portfolios by goal programming (Pendaraki et al. 2005).
(vi) Mean-semivariance efficient frontier (Ballestero 2005).
(vii) Hybrid models, neural networks and algorithms (Huang et al. 2006, 2013; Lin et al. 2006).

Some GP methods given uncertainty rely on chance constrained programming (CCP) (Charnes and Cooper 1959). CCP only allows the analyst to solve simple problems under precise conditions. Expected value models (EVM) involve minimizing the sum of a cost function and an extra cost function (recourse), but this approach is rather inappropriate (Liu 2009, ch. 5, pp. 62, 75). A different version is random fuzzy expected value models (Liu and Liu 2003). Genetic algorithms attempt to mitigate complexity in the above methods (Luhandjula 1989; Yazenin 1996). Satisfaction functions are proposed to integrate the decision maker's preferences into GP models under uncertainty (Aouni et al. 2005). Fuzzy techniques are useful when probability distributions are unknown (Abdelaziz and Masri 2005). Papers using (or referring to) EV-SGP are, among others, Chenglin and Hua (2001), Tozer and Stokes (2002), Bordley and Kirkwood (2004), Sahoo and Biswal (2005), Abdelaziz et al. (2007), Muñoz and Ruiz (2009), Bravo and Gonzalez (2009), and Muñoz et al. (2010).

The theoretical approach to SRI portfolio selection based on MV-SGP is applied to a wide opportunity set of 80 assets, of which 20 assets are ethical (green) funds. In this example, real world information is used, namely, time series of weekly returns, which involves accepting Sharpe's (1994) principle that historic results have predictive ability.

7.2 Defining Investor's Profiles

To provide precise information, an independent research organization in UK, The Experts In Responsible Investment Solutions (EIRIS), reports there are almost 100 green and ethical funds available to UK investors (year 2010) while there were just two dozen ethical funds 10 years ago. Currently, there are £7 billion invested in UK green and ethical retail funds – up from £1.5 billion 10 years ago (EIRIS 2010). Socially responsible mutual funds choose investments according not only to financial criteria but also to environmental, social and governance criteria (SEG), so that their investments reflect ethical values. In other words, socially responsible mutual funds rely on portfolios combining attractive profitable/risk with appropriate return for society rather than relying on ethical investment only (EIRIS 2010).

Environmentally responsible investment may be the most relevant SRI perspective. In the actual case to be developed hereafter, the ethical assets are green (environmental) investments.

Opportunity set S includes 80 assets, of which 20 are green while the remaining 60 are not categorized as ethical. Therefore, we have $F_i, i = 1, 2, \ldots 20$ for subset S^* and $F_i, i = 21, 22, \ldots 80$ for subset S^{**}. In this opportunity set, each asset is a fund, which is domiciled in the United Kingdom.

All the numerical information to be used on this opportunity set comes from the following sources: (a) data kindly provided to the authors by Morningstar Ltd; and (b) data on social responsibility of funds, available in EIRIS (2008).

Concerning ethical (environmental) investments, we consider some types of investor (or investor's profiles), who can be institutions, companies, mutual funds or individuals. They are defined as follows.

(i) *Strong green investor*. This profile is defined by the following criteria.

Criterion (a). High level of aspiration for the ethical (green) goal. More precisely, this profile is defined by $\lambda = 0.75$ in Eq. (6.8) (see previous chapter). Hence, ethical target becomes:

$$e_0 = 0.75 \bar{f}_{emax} = 0.75 \times 0.00226 = 0.00169 \quad (7.1)$$

where the numerical value of $\bar{f}_{emax}$ is obtained from Table 7.1, being equal to 0.00226.

Criterion (b). According to Sect. 6.4, the ARA coefficients are defined by the $r_1/r_2 = 1/2$ ratio, namely, $r_1 = 2/3$ and $r_2 = 1/3$ as normalized values.

(ii) *Weak green investor*. This profile is defined by the following criteria.

Criterion (a). Low level of aspiration for the ethical (green) goal. More precisely, this profile is defined by $\lambda = 0.25$ in Eq. (6.8). Hence, ethical target becomes:

$$e_0 = 0.25 \bar{f}_{emax} = 0.25 \times 0.00226 = 0.00056 \quad (7.2)$$

Table 7.1 Covariance matrices and vector of expected returns (fragment)

Matrix V_1						
1	2	...	20	21	...	80
0.00035	0.00026	...	0.00026	0.00039	...	0.00036
0.00026	0.00029	...	0.00027	0.00032	...	0.00028
...	...	...	...	...	...	...
0.00026	0.00027	...	0.00028	0.00033	...	0.00028
0.00039	0.00032	...	0.00033	0.00054	...	0.00041
...	...	...	...	...	...	...
0.00036	0.00028	...	0.00028	0.00041	...	0.00041
Matrix V_2						
1	2	...	20	21	...	80
0.00035	0.00026	...	0.00026	0	...	0
0.00026	0.00029	...	0.00027	0	...	0
...	...	...	...	...	...	...
0.00026	0.00027	...	0.00028	0	...	0
0	0	...	0	0	...	0
...	...	...	...	...	...	...
0	0	...	0	0	...	0
Vector of expected returns						
0.00167	0.00226	...	0.00138	...	...	0.00043

where the numerical value of $\bar{f}_{emax}$ is obtained from Table 7.1, being equal to 0.00226.

Criterion (b). According to Sect. 6.4, the ARA coefficients are defined by the $r_1/r_2 = 3/4$ ratio, namely, $r_1 = 4/7$ and $r_2 = 3/7$ as normalized values.

7.3 Specifying and Solving the Model

As a previous step, weekly returns, mean values and covariances are computed. For each asset in the opportunity set, weekly returns from January 2001 to January 2006 are considered, so that 264 random returns are observed. From the random returns, covariance matrices and are computed. In Table 7.1, these matrices have been extracted, due to their large size. At the bottom of this table, the expected returns (or mean values) are displayed.

For profiles (i) and (ii), the model is stated as follows. From Eqs. (6.3) and (6.6) (see previous chapter), we have the objective function:

$$v = \min X(r_1 V_1 + r_2 V_2) X^T \tag{7.3}$$

where $r_1 = 2/3$ and $r_2 = 1/3$ for profile (i), while $r_1 = 4/7$ and $r_2 = 3/7$ for profile (ii), according to criterion (b) in the respective cases.

Minimization (7.3) is subject to the following constraints:

$$E_1 = 0.001668x_1 + 0.002259x_2 + \ldots + 0.000431x_{80} \geq g_0 \tag{7.4}$$

$$E_2 = 0.001668x_1 + 0.002259x_2 + \ldots + 0.001378x_{20} \geq e_0 \tag{7.5}$$

Target g_0 takes parametric values to obtain efficient frontiers. Targets $e_0 = 0.00169$ for profile (i) and $e_0 = 0.00056$ for profile (ii) are given by Eqs. (7.1) and (7.2), respectively.

To close the model, non-negativity conditions are added.

$$\sum_{i=1}^{80} x_i \geq 0 \tag{7.6}$$

Notice that diversification constraints are not needed because the assets in the opportunity set are all diversified funds.

Computation is easy by using Lingo GENPRT or by using MatLab with a format similar to the generic Markowitz portfolio.

7.4 Results

In Tables 7.2–7.4, the efficient portfolios obtained from model (7.3) to (7.6) for green profiles (i) and (ii) are displayed. For each green profile, each row in the table refers to an efficient portfolio, which is characterized by parameter g_0 and the respective v objective value (7.3), together with expected return E_2 given by (7.5).

Table 7.2 Results: efficient frontiers for strong green investors

g_0	v	XV_1X^T	$\sum_{i=1}^{20} x_i$
0.00185	0.00020	0.000216	0.81071
0.00190	0.00020	0.000217	0.80521
0.00195	0.00020	0.000219	0.79970
0.00200	0.00020	0.000222	0.79775
0.00205	0.00020	0.000225	0.79806
0.00210	0.00021	0.000228	0.79837
0.00215	0.00021	0.000231	0.79849
0.00220	0.00021	0.000235	0.79900
0.00225	0.00021	0.000239	0.79887
0.00230	0.00021	0.000243	0.79167
0.00235	0.00022	0.000249	0.77733
0.00240	0.00022	0.000256	0.76300
0.00245	0.00023	0.000269	0.75472

Table 7.3 Results: efficient frontiers for weak green investors

g_0	v	XV_1X^T	$\sum_{i=1}^{20} x_i$
0.00160	0.00010	0.000165	0.26570
0.00165	0.00010	0.000165	0.26170
0.00170	0.00010	0.000166	0.26154
0.00175	0.00010	0.000168	0.26135
0.00180	0.00011	0.000170	0.26117
0.00185	0.00011	0.000173	0.26096
0.00190	0.00011	0.000175	0.26085
0.00195	0.00011	0.000177	0.26092
0.00200	0.00011	0.000180	0.26098
0.00205	0.00011	0.000183	0.26104
0.00210	0.00011	0.000186	0.26112
0.00215	0.00012	0.000189	0.26115
0.00220	0.00012	0.000193	0.26115
0.00225	0.00012	0.000196	0.26109
0.00230	0.00012	0.000200	0.26104
0.00235	0.00012	0.000204	0.26095
0.00240	0.00013	0.000208	0.26087
0.00245	0.00013	0.000212	0.26077
0.00250	0.00013	0.000216	0.26068
0.00255	0.00013	0.000221	0.26059
0.00260	0.00014	0.000225	0.26051

For every portfolio, the expected returns E_1 and E_2 turn out to be equal to targets g_0 and e_0, respectively, so that Eqs. (7.4) and (7.5) have zero slack.

To compare results for the green profiles to results for the traditional investor, the classical Markowitz's E-V efficient frontier is recorded in the last columns. As typically occurs in E-V models, some irregular portfolios appear for low levels of expectation, namely, the efficient frontier is a curve taking the standard bullet shape (Haugen 1990). These portfolios are removed from the table.

Information on the portfolio weights for each investor's profile and each efficient portfolio is also provided in Tables 7.2–7.4.

Results will be here analyzed in a comparison framework.

7.4.1 Achievement in Terms of Expected Return and Risk

From Tables 7.2 to 7.4, a comparison of efficient portfolios for strong green, weak green and traditional investors is made as follows.

Table 7.4 Results: efficient frontiers for traditional investors

g_0	XV_1X^T	$\sum_{i=1}^{20} x_i$
0.00150	0.000152	0
0.00170	0.000156	0
0.00175	0.000158	0
0.00180	0.000160	0
0.00185	0.000162	0
0.00190	0.000165	0
0.00195	0.000167	0
0.00200	0.000170	0
0.00205	0.000173	0
0.00210	0.000176	0
0.00215	0.000180	0
0.00220	0.000183	0
0.00225	0.000186	0
0.00230	0.000190	0
0.00235	0.000194	0
0.00240	0.000198	0
0.00245	0.000202	0
0.00250	0.000206	0
0.00275	0.000229	0
0.00300	0.000261	0

(a) Traditional investors can reach feasible portfolios of high expectation such as $g_0 = 0.00300$. In contrast, strong green investors can only reach portfolios with at most 0.00245 expected return. This is a drawback of strong green investment. In the case of weak green investors, the highest feasible portfolio has $g_0 = 0.00290$, which is close to the highest feasible for traditional investors.

(b) Concerning risk, let us compare the three columns "var" for the three investor's profiles in Table 7.2. We see that the risk level for strong green investors is significantly higher than for traditional investors, other things being equal (namely, when expected return g_0 is kept at the same level). Therefore, traditional investment outperforms strong green investment from the classical (Sharpe 1994) ratio, namely, from a financial performance perspective. Weak green investment ranks between traditional and strong green investment – its risk levels are closer to those of traditional investors than those of the strong green ones.

7.4.2 Portfolio Weights: A Comparison from the Green Perspective

In Tables 7.2–7.4, we see that the sum of the portfolio weights corresponding to green assets ranges as follows:

$$0.75 \leq \sum_{i=1}^{20} x_i \leq 0.81 \quad \text{for strong green investors} \tag{7.7}$$

$$0.25 \leq \sum_{i=1}^{20} x_i \leq 0.27 \quad \text{for weak green investors} \tag{7.8}$$

$$\sum_{i=1}^{20} x_i = 0 \quad \text{for traditional investors} \tag{7.9}$$

Therefore, the strong green portfolios invest in green assets about three times as much as the weak green portfolios do. In both cases,it generally (but not always) occurs that the higher the expected return g_0 the lower the sum of the portfolio weights corresponding to green assets. In the case of traditional investors, zero investment in green assets is obtained from the model. These results are perfectly consistent indeed.

7.5 Sensitivity Analysis

Firstly, consider the case of strong green investors.

What if target e_0 increases/decreases by 10 %? Then, small changes in the portfolio weights (around 0.04 in average) are obtained, except for portfolios of high expected return in which changes in the portfolio weights reach between 0.12 and 0.16.
What if ARA coefficients $r_1 = 2/3$ and $r_2 = 1/3$ would change to 2.20/3 and 0.80/3, respectively? What if these ARA coefficients would change to 1.80/3 and 1.20/3, respectively? In both cases, no significant changes are observed.

Secondly, consider the case of weak green investors.

What if target e_0 increases/decreases by 10 %? Then, changes in the portfolio weights are very small (around 0.012 in average), except for portfolios of high expected return in which changes in the portfolio weights reach between 0.25 and 0.32.

What if ARA coefficients $r_1 = 4/7$ and $r_2 = 3/7$ would change to 4.20/7 and 2.80/7, respectively? What if these ARA coefficients would change to 3.80/7 and 3.20/7, respectively? Then, no significant changes are observed.

Conclusions

This application can be viewed as an innovative application of OR, which "can convince managers of the value to be gained by applying OR to SRI portfolio selection". Indeed, we have undertaken a large scale problem of green portfolios. Numerical results given in Tables 7.2–7.4 are consistent. Concerning the framework of our example (without generalizing to other contexts), these results show that strong green investment in the portfolios involves more financial risk than weak green investment, other things being equal. This would mean some drawback for strong ecological investors. Such a question should be investigated further, i.e. on data sets other than the ones used in this paper.

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Part III
Compromise Programming and SRI Funds

Chapter 8
Compromise Programming and Utility Functions

Enrique Ballestero and Ana Garcia-Bernabeu

Abstract Proposed in the last decades of the twentieth century, the Compromise Programming (CP) model assumes that the decision maker looks for a compromise between objectives of different character, financial, ethical or others. As described by CP, the decision maker has in mind an ideal point, which is a basket containing the best feasible level of each objective. This ideal is a utopian infeasible basket of reference because all the best objectives cannot be simultaneously reached. Given an efficient frontier of baskets, the CP satisfying solution is to choose the basket closer to the ideal. More precisely, the CP solution is obtained by minimizing the distance between a frontier basket and the ideal. Distances are not necessarily measured by the Euclidean quadratic metric but by a conventional metric between one and infinity. Moreover, the distance in CP is not a purely geometric notion but a composite measure in which the geometric components are multiplied by the decision maker's preference weights for each objective. Years later the CP proposal, a linkage between CP and utility theory was investigated. Finally, Linear–quadratic composite metric looks for a compromise between aggressive (large risky acnievements) and conservative (balanced solutions) objectives.

8.1 Introduction to CP Modelling

To deal with a variety of MCDM methods assures competitiveness and complementarity, so that the use of a broad range of methods should not be abruptly reduced to one or a few. Together with GP and other techniques, CP is appropriate to make decisions in many fields such as finance, engineering, management and so on. Given that no method can be presented as superior to others, each of them is useful depending on environments and circumstances. Take, for example, classic lexicographic and weighted goal programming, which are the most usual goal

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programming models (Tamiz et al. 1995). They are especially appropriate for management scenarios in which the decision maker (DM) seeks “satisficing” solutions of bounded rationality by subjectively introducing a profusion of targets. In contrast, CP and multi-objective programming are more appropriate for finance/engineering scenarios where the DM cannot afford to replace objective information by subjective views, although the principle of bounded rationality is still accepted in a moderate way. Briefly speaking, CP raises the following optimization problem: to find the efficient alternative closest to a referential infeasible alternative, named utopia, ideal or anchor value. In greater detail, the characteristics of CP are as follows:

(a) It requires specifying the efficient frontier, namely, an allocation set in which no variable can be made better off without making some other variable worse off.
(b) It considers the ideal as an analytic reference for optimization.
(c) This ideal is an infeasible point which generally derives from the efficient frontier, i.e., the CP ideal is a vector whose components are the best values (anchor values) of the criteria.
(d) Therefore, unlike goal programming, the CP ideal is not a target established by the DM from his own views and judgments.
(e) The CP solution is obtained by minimizing the weighted distance from each efficient point to the infeasible ideal, so that the DM chooses the efficient alternative closest to the utopia.
(f) Therefore, CP, although using preference weights, searches for an optimal solution rather than for a “satisficing” solution in the most literal sense of this word.

Assuring efficiency by finding the efficient frontier prior to selecting the optimal solution is the standard procedure used in economics (utility optimization, multi-objective programming models, etc.). In economics, the production possibility set (Pareto efficient frontier) is determined prior to optimizing utility by Lagrange maximization. However, the two-step model (efficient frontier first) can be reduced to a single step (direct optimization) in problems where the presence of inefficient solutions is directly discarded. Descriptively considered, CP embraces different meanings and representations, one of them being an arbiter who looks for a compromise between parties with conflicting interests or opposite standpoints (Ballestero 2000). To undertake the CP minimization, the analyst should previously specify the objective function as a distance equation depending on the chosen metric, which is not necessarily the usual Euclidean quadratic metric. Linear metric is appealing to DMs who seek large outcomes involving imbalanced solutions in exchange for balanced (non-corner) solutions. In contrast, higher metrics such as the quadratic one or even higher are more appealing to DMs who turn to the precautionary principle of avoiding corner solutions. An extreme metric for the balancing purpose is the infinity norm; however, its use might be inappropriate from the achievement perspective (Ballestero 1997). There is CP literature in which a method is provided to solve the metric selection problem. This method relies on a linkage between the CP metric and Arrow’s-Pratt’s risk theory (Arrow 1965; Pratt 1964). Nevertheless, such an approach cannot be properly used in our deterministic context (Ballestero and Romero 1998; Krcmar et al. 2005; Stokes and Tozer 2002; Xia et al. 2001).

A large amount of CP papers have been published in the academic literature. Currently, more than 18,000 articles can be found in ScienceDirect, which is one of the world's leading full-text scientific database, from which more than 1,300 are applications in finance and, in particular, more than 300 papers include applications of CP-based models to the portfolio selection problem. One of the pioneering applications of CP for portfolio selection are due to Ballestero and Romero (1996) and since then several interesting works can be found in the literature. Some recently published applications are: Bilbao-Terol et al. (2006a,b), Amiri et al. (2011), Abdelaziz et al. (2007a), Ballestero and Plà-Santamaría (2003, 2004), Ballestero et al. (2007) and Perez Gladish et al. (2007).

In this chapter, the problem takes a different turn. The approach is deterministic, which appears to be more appealing than to combine CP with risk and probability without an axiomatic basis.

8.2 Choice Problems and the Decision Maker's Utility

In economics, utility is the cornerstone of classical and modern theory. This concept derives from Bentham's thought, which is known as utilitarianism. Economists assume utility maximization, which is stated as follows:

$$\begin{aligned} &\max Z = Z(x_1, x_2) \\ &\text{subject to } T(x_1, x_2) = k \end{aligned} \tag{8.1}$$

where (x_1, x_2) represents a choice for the decision-maker (e.g. commodity–mix in a consumer's choice problem, vector of outputs in a joint production problem, composition of a portfolio of securities, etc.); $Z(x_1, x_2)$ is the utility function for the decision-maker, and $T(x_1, x_2) = k$ is the attainable or feasible set (budgetary boundary in consumer theory, transformation curve in joint production problems, efficient frontier in portfolio analysis, etc.).

The essence of microeconomic analysis lies within structure (8.1). Thus, economic rationality is usually defined in terms of maximizing a consistent and transitive function such as $Z(x_1, x_2)$ subject to the satisfaction of the feasible set. This approach has long been used because of its elegance, although its empirical value is doubtful for practical reasons. Implementation of traditional analysis requires one obtaining a reliable mathematical representation of $Z(x_1, x_2)$ which demands very precise information not available in many scenarios. In other words, $Z(x_1, x_2)$ is often unknown. For example, an economist can rarely deal with a consumer's empirically elicited utility function, and still less with an empirical social utility function.

Moreover, it might be useful to remember that the logical soundness of the utility function has been severely criticized in several decision contexts. Some of the assumptions necessary to the acceptance of the existence of a utility function (comparability, reflexivity, transitivity, and continuity of preferences) seem questionable; e.g. the continuity of preferences in many decision making problems within the field of natural resources planning. However, this controversial topics will not be considered in the present paper. We do not seek to modify the core of the traditional paradigm since it is commonly accepted in the literature and has proved its explanatory power for the economist's intellectual necessities. On the contrary, we are looking for a bridge between utility functions and operational research, improving the potentiality of the traditional paradigm in economic applications.

8.3 Reviewing the CP Model

A first task in CP is to define the ideal point, also called the point of anchor values. This ideal is an infeasible utopian target, in which each CP variable reaches its optimum. No decision maker can optimize all the variables simultaneously. Imagine your ideal is to drive your car as fast as possible and simultaneously to minimize road accident risk, but this utopian aspiration is quite impossible to achieve. Then you look for a compromise between speed and security. Consider the following example related to SRI policies: A country which can produce food of two different types of farming:

(a) Organic food by agricultural systems that do not use chemical fertilizers and pesticides. This farming involves an SRI objective.
(b) Conventional food from crops in which chemical fertilizers and pesticides are used. This farming does not involve an SRI objective.

By allocating all the agricultural resources to organic food, the country can attain x_1^* units of food, whereas by allocating all the agricultural resources to conventional food, the country can reach x_2^* units. Hence, the obviously unattainable utopian basket (x_1^*, x_2^*), would be the CP ideal point. The country's dream consists in simultaneously producing x_1^* organic food and x_2^* conventional food; however, this dream is impossible. Indeed, the country can produce a mix (x_1, x_2) such as $T(x_1, x_2) = k$, where T is an efficient frontier whose extreme points are $(x_1^*, 0)$ and $(0, x_2^*)$.

Under similar situations, the basic structure of a CP choice is not (8.1) but the following alternative, which is not devoid of realism:

$$\begin{aligned} &\max Z = Z(x_1, x_2) \\ &\text{subject to } T(x_1, x_2) = k \end{aligned} \tag{8.2}$$

where $C_O(x_1, x_2)$ means the search for an compromise point along the T frontier. There is not a single rigid criterion for solving (8.2). Among many others, a simple way of compromising is obtained by taking:

$$x_1/x_1^* = x_2/x_2^* \tag{8.3}$$

However, there is a general criterion which is widely accepted in the literature: the decision-maker seeks a compromise solution as close as possible to the ideal point, the so called Zeleny's axiom of choice (Zeleny 1982). To achieve this closeness, a family of distance functions is introduced into the analysis. In consequence, the structure of a CP problem under Zeleny's axiom can be summarized as follows:

$$\begin{aligned} &\min L_p = [w_1^p(x_1 - x_1^*)^p + w_2^p(x2 - x_2^*)^p]^{1/p} \\ &\text{subject to } T(x_1, x_2) = k \\ &0 \le x_1 \le x_1^*, \quad 0 \le x_2 \le x_2^* \end{aligned} \tag{8.4}$$

where (x_1^*, x_2^*) is the ideal point which is usually derived from $T(x_1^*, 0) = k$ and $T(0, x_2^*) = k$; (w_1, w_2) is the vector of weights attached to both magnitudes; and p is a parameter defining the family of distance functions $1 \le p \le \infty$.

In CP, weights w_1 and w_2 can play two different roles: (i) shadow prices for normalizing both x_1 and x_2 magnitudes in order to make their aggregation possible; (ii) preferential indexes, when utility functions are not considered in the analysis. In this paper weights will only be used for normalizing purposes, since utility functions involve the preferential scheme.

For several values of the parameter p different baskets which are closest to the ideal point are obtained. Yu (1973) demonstrated that for the bi-criteria case the distance function L_∞, is monotone nondecreasing for $1 \le p \le \infty$. Thus, L_1 and L_∞ metrics define a subset of the attainable frontier, known as the compromise set.

The other best-compromise solutions fall between those corresponding to L_1 and L_∞ metrics, i.e., $L_p \in [L_1, L_\infty]$. Baskets on the compromise set enjoy some useful economic properties, such as feasibility, Paretian efficiency, independence of irrelevant alternatives, etc. (Yu 1985, Ch.4)

It is worth pointing out that Eq. (8.3) is a particular case of Eq. (8.4) when $p = \infty$ and weights are inversely proportional to the values (i.e. $w_1/w_2 = x_2^*/x_1^*$) as can easily be proved (see Ballestero and Romero 1991).

8.3.1 *An Example of CP Setting from Economic and Ethical Objectives*

Political leaders in a country usually pursue economics growth policies together with ethical policies. Electors and media can then wonder if the political programs are able to combine economic and ethical objectives in a coherent way by looking for a compromise between goals. Those programs which promise an ideal achievement of maximizing incompatible goals are not earnest and can be judged as demagogic. Suppose that the Y party is preparing an electoral program from the following objectives.

(i) Economic policy. To increase Gross Domestic Product (variable x_1) as much as possible. Domestic product to be reached should not be less than x_{1*} expressed in real terms to assure a reasonable income guaranteeing a decent standard of living to people.
(ii) Ethical policy. To increase environmental protection (variable x_2) as much as possible. This is needed to meet targets such as sustainable growth, rational use of natural resources, health, and low pollution. For this purpose, the index of environmental protection should not be less than x_{2*} scalarized units.

This involves a trade-off between (i) and (ii), so that more x_2 can be only obtained in exchange for less x_1 and viceversa. Electoral programs should consider the moral impossibility of promising ideal paradises, which overlook the trade off. In mathematical terms the trade off is measured on the Paretian efficient frontier (8.1), namely:

$$T(x_1, x_2) = k$$

In Fig. 8.1, curve *ABCD* represents this trade-off in its general formulation. Since more x_1 implies less x_2, the curve is decreasing. Concerning concavity, the shape of the curve is highlighted as follows. If x_1 has a value close to 0, then x_1 can strongly increase in exchange for a slight loss of x_2. Therefore, we have an almost horizontal slope at point D. On the contrary, suppose that x_1 reaches a high value close to OA. Then, slight increments in x_1 involve abrupt losses of x_2, so that the slope at point A is almost vertical.

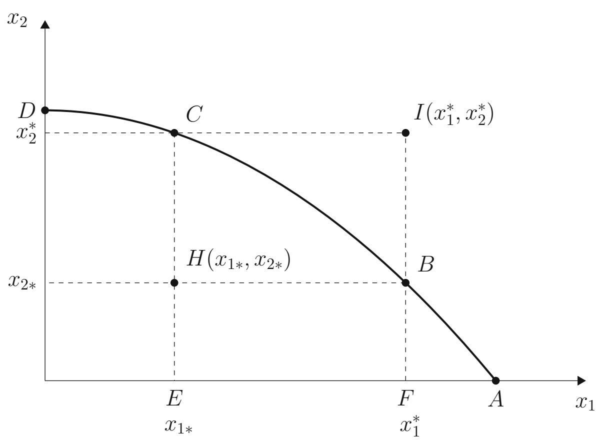

Fig. 8.1 Gross Domestic Product and environmental protection dilemma: CP setting

Figure 8.1 describes the CP setting. Ideal point $I(x_1^*, x_2^*)$ and anti-ideal point $H(x_{1*}, x_{2*})$ are graphed in connection with the efficient frontier.

OE is the minimum level of gross domestic product to assure acceptable lower limits for consumption, investment and employment. This is the x_{1*} anti-ideal value. Vertical line EC determines the ideal or anchor value $x_2^* = FI$.
OG is the minimum level of environmental protection to assure acceptable lower limits for critical environmental parameters. This is the x_{2*} anti-ideal value. Horizontal line GB determines the ideal or anchor value $x_1^* = FI$.

Given preference weights w_1 and w_2 for objectives (i) and (ii), the compromise solution is the frontier point which minimizes distance (8.4).

There is an ongoing issue that movements along the frontier curve can cause changes in this frontier. As shown in Fig. 8.2, the frontier could then shift upward to position $A'B'C'D'$ or downward to position $A''B''C''D''$. Consider a CP setting in which x_1 is company's income in aggregate terms while x_2 is an index of social protection including social security, subsidies, holidays and any other government initiative of social welfare. Conservative parties contend that the frontier curve will shift downward if x_2 is set high. This is because high levels of social protection discourage private investment. If so, social protection could finally turn out to be less than before due to downward shifts. Social democratic parties do not agree with this paradox. They contend that the frontier curve will keep unchanged or will shift upward because productivity increases with social welfare. To look into pros and cons of these political programs lies outside the limits of this book.

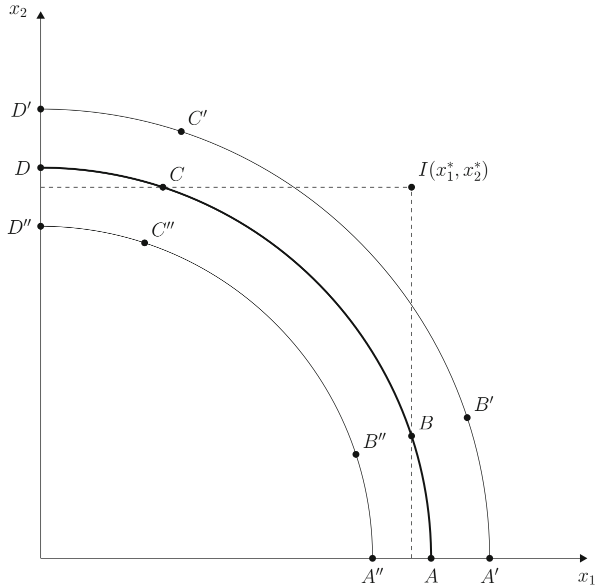

Fig. 8.2 Company's income and social protection dilemma: Frontier shifting

8.3.2 CP Proxy for the Decision Maker's Utility Function

Now, our purpose is to show how to use CP model (8.4) to help solve difficult problem (8.1). Before rushing into formal statements, we will highlight the issue in an intuitive way. To minimize CP distance (8.4) is equivalent to maximizing the following CP utility function:

$$\max((w_1 \, x_1)^P + (w_2 \, x_2)^p)^{1/p} \tag{8.5}$$

under satiation conditions $x_1 \le x_1^*$ and $x_2 \le x_2^*$

CP utility (8.5) is non-linear non-additive for p values other than 1. It is worth noting that additive utility does not satisfy important properties in economic analysis. Satiation at the ideal point is also meaningful. Given a utility map, satiation means that you will reach a utility top. To assume the existence of this utility top is more realistic that assuming non-satiation, which would involve that you will never reach the top.

As proven in the MCDM literature, the CP maximum (8.5) lies on the Yu compromise set on the T efficient frontier. This property is extended by the following theorem:

Theorem 1 *Under plausible assumptions, the Lagrangean maximum of utility Z with two attributes lies on the Yu compromise set on the T efficient frontier.*

A proof can be found elsewhere. See e.g. Ballestero and Romero (1991).

8.3.3 SRI Example: Carbon Pollution from a Power Plant

Imagine a conventional thermal power plant which uses coal as energy source. Pollution from this plant is very high. This specially affects tourists in the summer and people living in the area who spend leisure time outside their homes. Faced with this problem, the manager of the power company looks for a compromise between environmental and profitability goals, which are defined as follows.

(i) Environmental objective. To stop the activity of the plant for some weeks in the summer.
(ii) Profitability objective. To work the remaining weeks of the year.

Hereafter, we denote by h_1 and h_2 the yearly hours of activity and temporary closure time, respectively.

According to the European Emission Trading Scheme (EU ETS), a CO_2 emission limitation target C_0 tonnes per year is established for this kind of power plants. Let

C be the yearly level of CO_2 pollution from the plant. In this legal framework, the following cases can occur:

(a) $C = C_0$. As the pollution level from the plant is equal to the target, the company is authorised to work during the year without incurring any penalty. The company does not receive any premium either.
(b) $C > C_0$. Then, the company's activity is authorised if and only if the company purchases Certified Emission Reduction credits (CERs) for the gap $(C - C_0)$ from the primary market. These purchases are made at price P established by the competitive market, which involves an extra cost of $P(C - C_0)$ monetary units for the company.
(c) $C < C_0$. Then, the company can sell CERs amounting to $(C_0 - C)$ in the primary market at price P, which means an extra earning of $P(C_0 - C)$ monetary units for the company.

Annual earnings after interest, taxes, depreciation and amortization are:

$$Y = y(1 - t)h_1 + P(C_0 - C) = y(1 - t)h_1 + P(C_0 - ch_1) \tag{8.6}$$

where y denotes earnings per hour after interest, amortization and depreciation but before taxes; t denotes corporate tax rate; and c is CO_2 pollution per hour from the plant.

To look for a compromise between objectives (i) and (ii), the following CP model is formulated. See setting in Fig. 8.3.

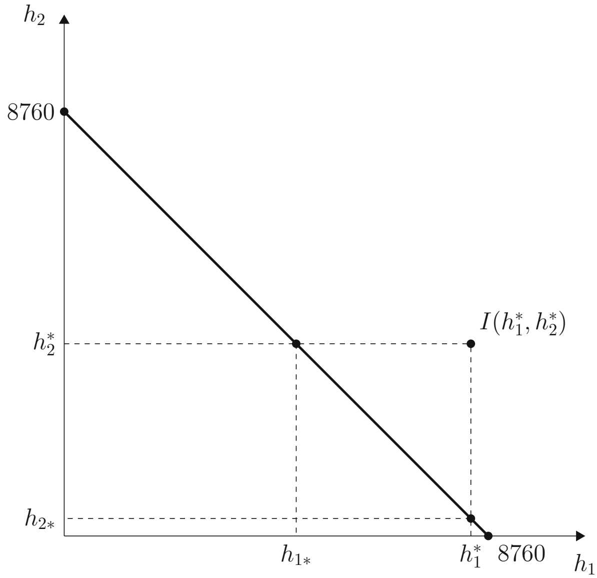

Fig. 8.3 CP setting and anchor values for environmental and profitability goals

$$h_1 + h_2 = 365 \times 24 = 8{,}760 \text{ hours per year} \tag{8.7}$$

Ideal point (h_1^*, h_2^*) and anti-ideal point (h_{1*}, h_{2*}) are stated as follows.

h_1^* is the maximum number of yearly hours to work by the plant. In our case, $h_1^* = (365 - 15) \times 24 = 8{,}400$ h, as the plant should stop for around 2 weeks for maintenance and control, regardless of the temporary closure time to meet environmental objective (i).

h_{1*} is the minimum number of yearly hours that the plant can work. To estimate it, we ask the company's manager on the minimum level of earnings that the company is willing to accept. Let Y_0 be this level. From Eq. (8.6), we have:

$$y(1-t)h_1 + P(C_0 - ch_1) \geq Y_0 \tag{8.8}$$

From Eq. (8.8) we obtain:

$$h_{1*} = \min h_1 = \frac{Y_0 - PC_0}{y(1-t) - cP} \tag{8.9}$$

where the variables took in year 2013 the following numerical values: $y = 4{,}500$ monetary units per hour; $t = 0.19$; $P = 4$ monetary units per CO_2 tonne, which was the market price for CERs; $C_0 = 10{,}000{,}000$ tonnes per year, which was the CO_2 emission limitation target for the plant; $c = 833$ tonnes per hour, which was CO_2 pollution from the plant; $Y_0 = 41{,}500{,}000$ monetary units a year. This amount was elicited by a dialogue between the analyst and the power plant manager who discloses that 41,500,000 monetary units was the minimum earning acceptable by the company. By specifying Eq. (8.9) with these numerical values, we get:

$$h_{1*} = \frac{41{,}500{,}000 - 4 \times 10{,}000{,}000}{4{,}500(1 - 0.19) - 833 \times 4} = 4{,}792$$

Moreover, we have:

$$h_1^* + h_{2*} = 8{,}760 \; h_{1*} + h_2^* = 8{,}760$$

These equations yield:

$$h_{2*} = 8{,}760 - 8{,}400 = 360 \quad \text{hours per year}$$

$$h_2^* = 8{,}760 - 4{,}792 = 3{,}968 \quad \text{hours per year}$$

From this setting, the CP model is defined as follows:

$$\begin{aligned}&\min = [w_1^p(8{,}400 - h_1^*)^p + w_2^p(3{,}968 - h_2^*)^p]^{1/p}\\&\text{subject to } h_1 + h_2 = 8{,}760\\&360 \le h_2 \le 3{,}968\end{aligned} \tag{8.10}$$

From preference weights $w_1 = 0.6$ and $w_2 = 0.4$ for the objectives, together with the Euclidean metric $p = 2$, this model is solved by Lingo 11.0, which yields $h_1 = 7{,}290$ h for the activity time and $h_2 = 1{,}470$ h for the temporary closure time.

A sensitivity analysis can highlight robustness of the model with respect to metric p. If the decision maker's risk aversion for random changes in the variables is very strong, then a higher metric should be used. Readers can check the results.

8.4 Linear–Quadratic Composite Metric: Advanced Approaches

We here minimize the distance between utility at the CP ideal point and the utility at a frontier point on the criteria setting. This meaningful distance is treated by Taylor expansion around the ideal point, thus obtaining the linear–quadratic composite metric. Aggressive decision makers prefer large risky achievements but the conservative ones prefer prudent balanced solutions, which are far away from aggressive corner points. Linear–quadratic composite metric looks for a compromise between these aggressive and conservative objectives.

The manufactures are often interested in blending materials to achieve industrial products able to satisfy marketing criteria. Suppose a manufacturer who wants to obtain blends of materials by considering a set of marketing and SRI criteria such as quality standards, obsolescence, special necessities of customer segments, environmental requirements, and others. In this problem, every criterion can be associated with a decision variable. For example, a criterion such as environmental requirements is associated with a decision variable such as the amount of a given polluting material. From this correspondence, the level of the jth criterion can be measured by the x_j decision variable. The space of decision variables and the space of criteria coincide.

Let $(x_1, x_2, \ldots, x_j, \ldots, x_n)$ be a CP setting of criteria/decision variables, where every criterion behaves as "the more the better". Every x_j is greater than (or equal to) zero. In this setting, the ideal point is $I(x_1^*, x_2^*, \ldots, x_j^*, \ldots, x_n^*)$, where x_j^* is the highest feasible value of the jth criterion. As well known, the CP objective function is given by the distance function of metric p (between 1 and ∞) as follows:

$$Z = \left[\sum_{j=1}^{n} w_j{}^p (x_j^* - x_j)^p\right]^{1/p} \tag{8.11}$$

to be minimized subject to an efficient frontier and the non-negativity conditions, which is equivalent to:

$$\max U_Z = K - Z \tag{8.12}$$

subject to the efficient frontier, where K is a constant sufficiently large to assure that the difference (8.12) is positive. Function (8.12) has the meaning of a special utility function that will be called the Zeleny–Yu utility.

8.4.1 Utility Function: An Extended Approach

A question arises whether CP can be stated from more general utility functions than (8.12). Let

$$U(x_1, x_2, \ldots, x_j, \ldots, x_n) = \sum_{j=1}^{n} U_j(x_j) \tag{8.13}$$

be a general additive utility function of criteria on the CP map. From Eq. (8.13), consider the following constrained minimization:

$$\min \Delta = \sum_{j=1}^{n} U_j(x_j^*) - \sum_{j=1}^{n} U_j(x_j) \tag{8.14}$$

subject to the efficient frontier and the non–negativity conditions, where Δ is the deviation between the utility value at the ideal point and the utility value at a generic point on the efficient frontier.

Indeed, minimizing the Δ deviation can be viewed as the core of an extended compromise programming. A Taylor expansion around the ideal point with the Lagrange form of the remainder term converts Eq. (8.14) into:

$$\begin{aligned} \min \Delta = {} & \sum_{j=1}^{n} U_j(x_j^*) - \\ & \left[\sum_{j=1}^{n} U_j(x_j^*) + \sum_{j=1}^{n} U_j{}^{(1)}(x_j^*)(x_j - x_j^*) + 0.5 \sum_{j=1}^{n} U_j{}^{(2)}(\varepsilon_j)(x_j - x_j^*)^2 \right] \\ = {} & \sum_{j=1}^{n} U_j{}^{(1)}(x_j^*)(x_j - x_j^*) - 0.5 \sum_{j=1}^{n} U_j{}^{(2)}(\varepsilon_j)(x_j - x_j^*)^2 \end{aligned} \tag{8.15}$$

where $U_j^{(1)}$ and $U_j^{(2)}$ are the first and second partial derivatives of the utility function with respect to the jth variable, namely, the first and second derivatives of the utility term $U_j(x_j)$ of the additive function. Notice that expansion (8.15) does not state a mere approximate value but represents the exact value according to the following Taylor's theorem: the Lagrange form of the remainder term states that a numberε between x_j and x_j^* does exist if U_j is a function which is continuously differentiable on the closed interval $[x_j, x_j^*]$ and twice differentiable on the open interval (x_j, x_j^*).

Since the ε_j terms are unknown variables, we use a proxy for *min* Δ, which consists in replacing every ε_j by the respective x_j^* ideal value. Then, Eq. (8.15) becomes:

$$\min \Delta = \sum_{j=1}^{n} U_j(x_j^*) -$$

$$\left[\sum_{j=1}^{n} U_j(x_j^*) + \sum_{j=1}^{n} U_j{}^{(1)}(x_j^*)(x_j - x_j^*) + 0.5 \sum_{j=1}^{n} U_j{}^{(2)}(x_j^*)(x_j - x_j^*)^2 \right]$$

$$= \sum_{j=1}^{n} (-1) U_j{}^{(1)}(x_j^*)(x_j - x_j^*) - 0.5 \sum_{j=1}^{n} U_j{}^{(2)}(x_j^*)(x_j - x_j^*)^2 \qquad (8.16)$$

8.4.2 Normalizing the x_j Criteria

For practical convenience, each x_j criterion is normalized by the following equation:

$$y_j = \frac{x_j - x_{j*}}{x_j^* - x_{j*}} \qquad (8.17)$$

where x_j^* and x_{j*} are the ideal and anti-ideal values, respectively, while the normalized y_j ranges between 0 and 1. Therefore, the normalized ideal is $y_j^* = 1$ while the normalized anti-ideal is $y_{j*} = 0$ for all j. In the special and frequent case of zero anti-ideal, Eq. (8.17) becomes $y_j = x_j / x_{j*}$. Later, this normalization will be use to transform Eq. (8.16). Our next task is to specify the partial derivatives in an understandable CP language.

8.4.3 Normalizing the Objective Function

By normalizing the x_j variables according to the previous section, objective function (8.16) becomes:

$$\min \Delta = \sum_{j=1}^{n} U_j^{(1)}(1)(1 - y_j) - 0.5 \sum_{j=1}^{n} U_j^{(2)}(1)(1 - y_j)^2 \qquad (8.18)$$

8.4.4 Linear–Quadratic CP Achievement Function

The statement in Sects. 8.4.1–8.4.3 leads to a particular utility–based compromise objective function, which is called the linear-quadratic CP achievement (Ballestero 2007). This is interesting, not only for blend design but also to straightforwardly solve a wide range of compromise programs of management. Linear-quadratic CP achievement can be stated with any number of criteria. Hereafter, the analysis will be limited by considering only two criteria, as this special case often appear in managerial and finance applications. In the previous subsections, the CP approach has been entirely developed in a rather general utility framework. No particular type of utility, such as exponential, logarithmic, power or any other, has been used. However, to derive the linear-quadratic CP achievement in our context we use the classic Cobb–Douglas utility function U_{CD} with two criteria as an operational tool, namely:

$$U_{CD} = y_1^{V_1} y_2^{V_2}; \quad 0 \le V_1,\ V_2 \le 1; \quad V_1 + V_2 = 1 \qquad (8.19)$$

whose first and second partial derivatives specified at the ideal point $y_j^* = 1$ $(j = 1, 2)$ are:

$$\begin{aligned} U_{CD_j}^{(1)}(1) &= V_j \\ U_{CD_j}^{(2)}(1) &= V_j(V_j - 1); \quad j = 1, 2 \end{aligned} \qquad (8.20)$$

By introducing partial derivatives (8.20) into CP objective function (8.18), we obtain the linear-quadratic CP achievement function:

$$\begin{aligned} \min \Delta = {} & (V_1(1 - y_1) + V_2(1 - y_2)) + \\ & 0.5\left(V_1(1 - V_1)(1 - y_1)^2 + V_2(1 - V_2)(1 - y_2)^2\right) \end{aligned} \qquad (8.21)$$

which should be optimized subject to the normalized efficient frontier.

Parameters V_1 and V_2 have a clear meaning of preference weights for the respective criteria. This can be checked by rating utility (8.19) in its logarithmic form:

$$\log U_{CD} = V_1 \log y_1 + V_2 \log y_2 \tag{8.22}$$

Therefore, V_1 and V_2 can be elicited through a dialogue about preferences between the analyst and the decision maker. An example of this dialogue is as follows.

Analyst. Do you prefer the $j = 1$ criterion to the $j = 2$ criterion, or viceversa?
Decision Maker. I prefer $j = 1$.
Analyst. How much?
Decision Maker. I give 3 points to $j = 1$ and 2 points to $j = 2$.

From this dialogue, we get $V_1 = 3/5$ and $V_2 = 2/5$.

8.4.5 A Case of Polymer Industry

This section describes an example of industrial blending in which the manufacturer's decisions are made from marketing criteria rather than from SRI criteria. Later in this chapter, an example involving SRI objectives will be developed. In both examples, the linear-quadratic CP achievement (8.21) will be used.

Suppose a manufacturer who faces with the problem of blending three types of polymer fibers. The product should have two desirable properties, tenacity and elongation at break, which are the CP criteria. Let q_i $(i = 1, 2, 3)$ be the percentage of the ith fiber in the blend, these percentages being the decision variables. Laboratory experiments to evaluate and enhance the product design show that tenacity in the blend is governed by the following equation:

$$x_1 = 1{,}132 \left(\sum_{i=1}^{3} t_i q_i \right) - 0.012 \left(\sum_{i=1}^{3} t_i q_i \right)^2 \tag{8.23}$$

where t_i is tensile strength per unit of the ith fiber. In Eq. (8.23), the negative quadratic term is due to a synergy effect which negatively influences tenacity in the blend. Elongation at break is roughly evaluated by the equation:

$$x_2 = \sum_{i=1}^{3} e_i q_i \tag{8.24}$$

where e_i is elongation at break per unit of the ith fiber. In Table 8.1, both t_i and e_i values $(i = 1, 2, 3)$ are recorded. Note the high inverse correlation between

Table 8.1 Polymer fiber blends: Basic data and the efficient frontier

Fiber code	Efficient frontier																
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1	20	92	0.41	0.44	0.48	0.51	0.55	0.58	0.62	0.65	0.69	0.73	0.76	0.8	0.83	0.87	0.9
2	29	72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	64	21	0.59	0.56	0.52	0.49	0.45	0.42	0.38	0.35	0.31	0.27	0.24	0.2	0.17	0.13	0.1
x1			26.68	26.61	26.48	26.29	26.05	25.75	25.39	24.97	24.5	23.97	23.38	22.73	22.03	21.26	20.44
x2			50	52.5	55	57.5	60	62.5	65	67.5	70	72.5	75	77.5	80	82.5	85
y1			1	0.99	0.97	0.94	0.9	0.85	0.79	0.73	0.65	0.57	0.47	0.37	0.25	0.13	0
y2			0	0.07	0.14	0.21	0.29	0.36	0.43	0.5	0.57	0.64	0.71	0.79	0.86	0.93	1

Column description: (1) tensile strength, measured in Newton per square millimeter or Megapascal; (2) Elongation at break, measured in percentage; (3)–(17) 15 efficient blends with their corresponding tenacity (x_1) and elongation at break (x_2) values, as well as the respective normalized tenacity (y_1) and normalized elongation at break (y_2) values.

tenacity (ability of the product to withstand tension, measured in Newton per square millimetre) and elongation at break (ability to stretch, measured in percentage).

First step. Determine the efficient frontier by maximizing tenacity subject to parametric levels of elongation at break from Eq. (8.24) and the constraint:

$$\sum_{i=1}^{3} q_i = 1 \tag{8.25}$$

saying that the sum of percentages is equal to unity. The parametric values of elongation x_2 range between 50 and 85 with intervals of 2.5. If elongation decreases below 50, then tenacity decreases below 26.68, and therefore, elongation values lower than 50 should be discarded as they lead to results worse than the combination ($x_1 = 50; x_2 = 26.68$) (see Table 8.1). Moreover, if elongation increases above 85, then tenacity decreases below 20, and consequently, using fiber number 1 alone is better than using a blend (check this in Table 8.1, upper half). In sum, the trade-off between elongation and tenacity appears only over the range (50, 85).

Second step. Normalize (standardize) both x_1 and x_2 criteria by Eq. (8.17), where the ideal and anti-ideal values are 26.68 and 20.44 for tenacity, while they are 85 and 50 for elongation at break. In Table 8.1, bottom half, the normalized values y_1 and y_2 are displayed.

Third step. Elicit preferences and attitudes to imbalance by the dialogue stated in Sect. 8.4.4 for the special case $n = 2$, thus obtaining Y_1 % and $(100 - Y_1)$ % from the decision maker's answer. In Table 8.2, several possible answers are considered, and therefore, their corresponding Y_1 percentages are displayed as parametric values.

Fourth step. For each possible answer, minimize Eq. (8.21) once specified numerically with the respective Y_1 percentage, this minimization being subject to the normalized efficient frontier given in Table 8.1.

Results are shown in Table 8.2 for a scale of parametric values Y_1 from 0.1 to 99.9 %. As a robustness analysis, this table visualizes each interval of parameter Y_1 for which the solutions given by the composite metric do not change, the intervals being separated by horizontal lines. For comparison, the solutions with metrics $p = 1$ and $p = \infty$ are also recorded in the same table. As these results come from a mere example of two criteria, their validity is very limited. They are summarized as follows:

(a) Metric $p = 1$ gives a wide range of corner solutions with larger achievements. Therefore, this is not a fitting metric for decision makers with significant aversion to imbalance

Table 8.2 Solutions with the composite metric, metric 1 and the infinity norm for different Y_1 percentages

	Composite metric		$h = 1$		Infinity norm		
Y_1	y_1	y_2	y_1	y_2	y_1	y_2	*Error*
0.1	0	1	0	1	0	1	0.1
1	0	1	0	1	0	1	1
2	0	1	0	1	0	1	2
3	0	1	0	1	0	1	3
5	0	1	0	1	0.13	0.93	−2.3
10	0	1	0	1	0.13	0.93	2.4
15	0	1	0	1	0.25	0.86	−0.65
20	0	1	0	1	0.25	0.86	3.8
24	0	1	0	1	0.37	0.79	−0.84
25	0.13	0.93	0	1	0.37	0.79	0
27	0.13	0.93	0	1	0.37	0.79	1.68
28	0.25	0.86	0	1	0.37	0.79	2.52
29	0.25	0.86	0	1	0.37	0.79	3.36
30	0.37	0.79	0	1	0.37	0.79	4.2
35	0.37	0.79	0	1	0.47	0.71	−0.3
38	0.37	0.79	0.37	0.79	0.47	0.71	2.16
39	0.57	0.64	0.37	0.79	0.47	0.71	2.98
40	0.57	0.64	0.37	0.79	0.47	0.71	3.8
45	0.57	0.64	0.57	0.64	0.57	0.64	−0.45
46	0.57	0.64	0.57	0.64	0.57	0.64	0.34
47	0.65	0.57	0.73	0.5	0.57	0.64	1.13
48	0.73	0.5	0.73	0.5	0.57	0.64	1.92
49	0.73	0.5	0.73	0.5	0.57	0.64	2.71
50	0.73	0.5	0.73	0.5	0.57	0.64	3.5
57	0.73	0.5	0.85	0.36	0.65	0.57	1.46
58	0.73	0.5	0.85	0.36	0.65	0.57	2.24
59	0.79	0.43	0.9	0.29	0.65	0.57	3.02
60	0.85	0.36	0.9	0.29	0.73	0.5	−3.8
64	0.85	0.36	0.9	0.29	0.73	0.5	−0.72
65	0.85	0.36	0.9	0.29	0.73	0.5	0.05
66	0.85	0.36	0.9	0.29	0.73	0.5	0.82
67	0.9	0.29	0.94	0.21	0.73	0.5	1.59
70	0.9	0.29	0.97	0.14	0.79	0.43	−2.4
75	0.9	0.29	0.97	0.14	0.79	0.43	1.5
76	0.94	0.21	0.97	0.14	0.79	0.43	2.28
79	0.94	0.21	0.99	0.07	0.85	0.36	−1.59
80	0.97	0.14	0.99	0.07	0.85	0.36	−0.8
85	0.97	0.14	0.99	0.07	0.9	0.29	−2.15
86	0.97	0.14	0.99	0.07	0.9	0.29	−1.34
87	0.99	0.07	0.99	0.07	0.9	0.29	−0.53

(continued)

Table 8.2 (continued)

	Composite metric		$h = 1$		Infinity norm		
Y_1	y_1	y_2	y_1	y_2	y_1	y_2	*Error*
90	0.99	0.07	1	0	0.9	0.29	1.9
92	0.99	0.07	1	0	0.94	0.21	−0.8
93	1	0	1	0	0.94	0.21	0.05
99	1	0	1	0	0.99	0.07	0.06
99.9	1	0	1	0	1	0	−0.1

(b) Given the discrete frontier in this example, the infinity norm only provides rough solutions affected by errors of considerable magnitude. From the basic equation of the infinity norm:

$$Y_1 = (1 - y_1) = (100 - Y_1)(1 - y_2) \tag{8.26}$$

the error corresponding to each frontier point (y_1, y_2) is computed as the difference between both sides of this equation, namely:

$$e(Y_1) = Y_1(1 - y_1) - (100 - Y_1)(1 - y_2) \tag{8.27}$$

In Table 8.2, the rough solution given by the infinity norm for each Y_1 preference weight is the frontier point minimizing error (8.27) in the set of the 15 frontier points recorded in Table 8.1, last two rows. Indeed, the errors shown in the last column of Table 8.2 do not allow us to draw conclusions on the accuracy of results from the infinity norm, which appears to be rather inapplicable. In particular, the rough solution $y_1 = 0$ and $y_2 = 1$ for the first four rows in Table 8.2 is affected by a percentage error of 200 %, and therefore, using here the infinity norm is unacceptable. The same occurs with the last row of the table. Only for $Y_1 = 25$, zero error is obtained.

Conclusions

We describe Compromise Programming (CP) as a multicriteria technique related to utility. Because optimizing utility is quite difficult in practice, the existence of a linkage between utility U and CP is appealing to construct a CP proxy for utility optimization. Analytically, CP can be viewed as a method to maximize the decision maker's utility function subject to an efficient frontier of criteria an the non-negativity constraints in a deterministic context. The lack of information necessary to build a reliable utility function is mitigated by resorting to the technical information derived from the efficient frontier. Regarding MCDM literature we explain how the CP solution lies on the Yu compromise set on the T efficient frontier.

(continued)

A first application of CP considering economic and ethical objectives is developed. The CP setting represents the Gross Domestic Product and environmental protection dilemma. Indeed, to reach the maximum Gross Domestic Product together with the maximum environmental protection is a utopian infeasible basket of reference because these objectives cannot be simultaneously reached.

An SRI numerical example is presented in order to describe how to apply the CP technique. The manager in a thermal power plant looks for a compromise between environmental and profitability goals facing with the problem of defining time for activity and time for temporary closure. Ideal and antiideal points are established by the manager. Then, the CP model is formulated taking into account preferences for the objectives. The selected CP metric is the Euclidean metric $p = 2$.

Compromise programming (CP) is viewed as the maximization of the decision maker's additive utility function (whose arguments are the criteria under consideration) subject to an efficient frontier of criteria and the non-negativity constraints in a deterministic context. This is equivalent to minimizing the difference between utility at the ideal point and utility at a frontier point on the criteria map, a meaningful statement as minimizing distances to the utopia is the ethos of compromise programming. By Taylor expansion of utility around the ideal point, the distance to the utopia becomes the weighted sum of linear and quadratic CP distances, which gives us the composite metric. While the linear terms pursue achievement, the quadratic ones pursue balanced (non-corner) solutions. Because some decision makers fear imbalance while others prefer large achievements even to the detriment of balance. Section 8.4 defines an aversion to imbalance ratio, so that the composite linear-quadratic metric should conform to this ratio depending on the decision maker's preferences and attitudes.

This composite metric seems to be appealing to analysts and users, not only because of its utility foundation but also because practitioners can easily specify the objective function without undertaking the unsolved problem of determining the best metric.

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Chapter 9
Portfolio Selection by Compromise Programming

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Abstract CP is a deterministic model like WGP in this aspect. Therefore, CP seems inappropriate to select stock portfolios from the Eu(R) maximization theory. In contrast to MV-SGP model, CP does not generalize Markowitz M-V model to multiple objectives. This lack of strictness is mitigated by the linkage between CP and utility theory established in Chap. 8. This linkage allows us to extend utility properties to CP approaches. We show the CP setting for portfolio selection by establishing and graphing its main elements: profitability-safety efficient frontier, ideal point and the bounds of Yu compromise set, which is the landing area on which the profitability-safety utility function reaches its maximum. From these variables, expected return and safety, the portfolio selection problem is defined in terms of CP.

9.1 Using CP to Select Securities Portfolios

The idea of determining the Paretian efficient frontiers to portfolio selection from mean-variance optimisation was conceived by Markowitz (1952). The mean-variance model was presented as a normative/descriptive model relying on plausible assumptions, namely, (i) risk is the investor's main concern, (ii) risk is associated with volatility, and (iii) the investor tries to minimize risk under the constraint of achieving a desired level of expected return (profitability constraint). This is the essence of mean-variance model, an approach widely discussed by Tobin (1958), Feldstein (1969), Levy (1974), and Hanock and Levy (1969). Despite

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controversies, the applicability of mean-variance is not seriously hurt nowadays. An alternative, but not a substantially different model is mean-absolute deviation (Konno and Yamazaki 1991). Other criteria/techniques used in portfolio selection are stochastic dominance (Copeland and Weston 1988, pp. 92–95) and skewness (Elton and Gruber 1984, pp. 236–238), both of difficult applicability, as well as geometric mean maximisation (Elton and Gruber 1984, pp. 218–222) and safety first, which leads to efficient portfolios under precise conditions. Currently, the so-called "modern portfolio theory" (MPT) follows a diversity of directions, including heuristic approaches (Balzer 1994; Sortino and Price Lee 1994; Sortino and Forsey 1996; Nawrocki 1999). In recent years a wide range of literature has been developed in the field of MCDM and portfolio selection. A review of this literature is made in Xidonas et al. (2012). Despite these meaningful contributions mean-variance maintains its cornerstone position. Mean-variance is considered as an initial step in portfolio selection. Once the mean-variance efficient frontier has been derived, the following problem arises: how to select the optimum portfolio among the various feasible portfolios lying on the efficient frontier. Typically, variance increases (decreases) as the mean increases (decreases) along the frontier. In other words, risk (as measured by variance) and expected return (as measured by mean) move together along the efficient curve. The investor can hardly discriminate between two efficient portfolios A and B, if both mean and variance are larger in A than in B. Then, the analyst can only distinguish between A and B by eliciting the investor's preferences for each portfolio. Hence, a precise knowledge of the investor's utility function reflecting his preferences would be required to select the optimum portfolio. However, to obtain this utility function is a major problem since its form and parameters often change markedly from investor to investor. From empirical information, Kallberg and Ziemba (1983) make a comparison of different utility functions to test whether functions with similar Arrow's absolute risk aversion coefficients (Arrow 1965) lead to similar optimal portfolios.

Difficulties raised by utility optimization could justify to some extent the use of operational research techniques such as multi-objective and goal programming models (see, e.g., L. and Lerro 1973, Kumar and Philippatos 1979, and Arenas-Parra et al. 2001) for portfolio construction purposes. Besides, goal programming approaches to project selection often appear in the operational research literature (Mukherjee and Bera 1995; Kim and Emery 2000; Badri et al. 2001). However, there are significant reasons to address the portfolio-selection problem by proposing models other than multi-objective/goal programming techniques. From the standard approaches to finance, a major reason is that multi-objective and goal programming approaches do not approximate the investor's utility optimum with a utility function characterized by risk aversion. Therefore, they are a great departure from the standard approaches to portfolio selection in the financial literature. If the utility focus is either neglected or wrongly addressed by using linear/additive utility forms, then the solutions are not suitable from a financial perspective (Copeland and Weston 1988). Linearity/additivity hypotheses were dropped from the earliest versions of utility in economics and finance because additivity entails an unrealistic description of preferences, namely, economists contend that the utilities provided by the attributes are not independent but interrelated. Linearity does not only break the condition of interrelated utilities but also involves risk neutrality in place of risk aversion. In this chapter, the standard utility approach is basically maintained as required in finance. To overcome the above-mentioned difficulties concerning the utility optimum and its operational determination, we use theorems connecting this optimum with the compromise programming (CP) model (Zeleny 1982; Yu 1985). A first theorem of connection is found in Ballestero and Romero (1996) while a second property guaranteeing a linkage between utility and CP for investors with particular preferences for profitability and risk is given in Ballestero (1998). Other papers extending these results have been recently published (Moron et al. 1996; Blasco et al. 1999; and Blasco et al. 2000). Under incomplete information on the utility form, the cited theorems prove that the investor's utility optimum can be bounded on the efficient frontier, the bounds being determined by CP techniques. In the financial problem of portfolio choice there are two standard criteria to be considered: profitability and risk. Profitability is measured by portfolio expected return while risk by portfolio variance. A significant previous step is to determine the efficient frontier by Markowitz's mean-variance model (Markowitz 1970, 1987). This model, in which matrices and vectors are written in bold, is stated as follows:

$$\min V = \mathbf{XVX}' \tag{9.1}$$

subject to

$$\bar{E} = \mathbf{EX}' \geq e_0 \tag{9.2}$$

$$\sum_{i=1}^{m} x_i = 1 \tag{9.3}$$

where

X is the vector of portfolio weights $(x_1, x_2, \ldots \text{x}_i, \ldots \text{ x}_m)$.
V is the mxm covariance matrix of returns on the assets.
X′ is the transposed vector of **X**.
E is the $1xm$ row vector of expected returns from the assets.
e_0 is the investor's target for E. To determine the efficient frontier, target e_0 is viewed as a parameter which takes feasible values.

For each numerical value of parametric target e_0, the model gives us the portfolio expected return and the variance V, thus obtaining the $T(\bar{E}, V) = k$ efficient frontier. To convert $T(E, V)$ into a profitability-safety efficient frontier $T(E, S) = k$, we make the change:

$$E = \bar{E} - \bar{E}_{min} \tag{9.4}$$

$$S = V_{max} - V \tag{9.5}$$

Variables E and S are normalized by the following indices:

$$\theta_1 = (\bar{E} - \bar{E}_{min})/(\bar{E}_{max} - \bar{E}_{min}) \tag{9.6}$$

$$\theta_2 = (V_{max} - V)/(V_{max} - V_{min}) \tag{9.7}$$

Obviously, $0 \leq \theta_1 \leq 1, 0 \leq \theta_2 \leq 1$.

With these normalized indices, the ideal point is ($\theta_1^* = 1$, $\theta_2^* = 1$) and the anti-ideal is (0,0).

From expected return E and safety S defined in Eqs. (9.4) and (9.5) respectively, the portfolio selection problem is defined in terms of CP as follows:

$$\min L_p(w_1, w_2) = ({w_1}^p (E^* - E)^p + {w_2}^p (S^* - S)^p)^{1/p} \tag{9.8}$$

subject to efficient frontier $T(E, S) = k$ where:

E^* = ideal or anchor value for expected return. This is E_{max}, namely, the largest expected return compatible with the constraints of the problem.
S^* = ideal or anchor value of safety. This is S_{max}.
w_1, w_2 = weights attached to criteria E and S, respectively.
p = CP metric. This is the parameter defining the family of CP distance functions.
$L_p(w_1, w_2)$ = CP solution with metric p and $(w_{1,}\ w_2)$ weights.

For $p = 1$, model (9.8) becomes:

$$\min L_1(w_1, w_2) = (w_1(E^* - E) + w_2(S^* - S)) \tag{9.9}$$

subject to efficient frontier $T(E, S) = k$.

By solving model (9.9), compromise portfolio is obtained.

For $p = \infty$, we have:

$$\min L_\infty(w_1, w_2) = \lim_{p \to \infty} ({w_1}^p (E^* - E)^p + {w_2}^p (S^* - S)^p)^{1/p} \tag{9.10}$$

subject to efficient frontier $T(E, S) = k$.

Limit (9.10) is proven to yield:

$$w_1(E^* - E) = w_2(S^* - S) \tag{9.11}$$

Straight line (9.11) through the (E^*, S^*) ideal point is called the infinity norm. See Ballestero and Romero (1991).

As proven by Yu (1973), every CP solution for any p metric lies on a frontier arc bounded by $L_1(w_1, w_2)$ and $L_\infty(w_1, w_2)$. This is called the compromise set.

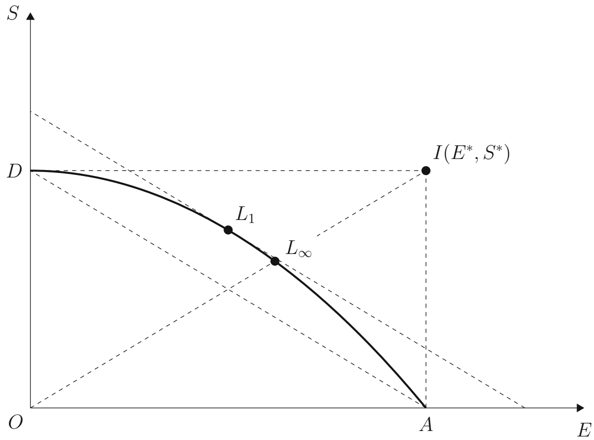

Fig. 9.1 Portfolio choice by CP: Normalized setting

If normalized indexes θ_1 and θ_2 are used, then Eqs. (9.8)–(9.11) turn into:

$$\min L_p(w_1, w_2) = ({w_1}^p(1-\theta_1)^p + {w_2}^p(1-\theta_2)^p)^{1/p} \tag{9.12}$$

$$\min L_1(w_1, w_2) = w_1(1-\theta_1) + w_2(1-\theta_2) \tag{9.13}$$

$$w_1(1-\theta_1) = w_2(1-\theta_2) \tag{9.14}$$

where every minimization is subject to efficient frontier $T(E, S) = k$.

In Fig. 9.1 the CP setting in terms of normalized indexes is represented. The main characteristics of this figure are: (a) the best attainable values of normalized profitability and safety are $OA = OD = 1$, which does not involve symmetry in the shape of the efficient curve; and (b) the preference weights for profitability and safety are generally unequal.

From Theorem 1 in Sect. 8.3.2, the family of investor's utility curves reaches its maximum feasible value on the frontier arc bounded by points $L_1(r_0)$ and $L_\infty(r_0)$, where $r_0 = w_1/w_2$ is the preference weight ratio for profitability and safety. This landing frontier arc is the Yu compromise set, on which every solution lies. In the special case of equal weighting, the landing arc turns out to be (L_1, L_∞), these bounds being represented in Fig. 9.1.

9.2 A Real World Case of Stock Market Investment

In this retrospective analysis, the opportunity set includes 104 stocks quoted on the Madrid Stock Market and classified in 23 business sectors over the 1992–1997 time horizon. Although the original opportunity set included 142 stocks, we have had to removed 38 of them due to mergers and lack of price information.

In Table 9.1, the 104 firms are recorded. We only select stock portfolios, although less risky portfolios combining bonds and stocks can be designed from the risk-profitability portfolios previously selected.

Table 9.1 Opportunity set: 104 companies listed on the Madrid Stock Market (1992–1997)

N	SECTOR	COMPANY	CODE
1	WATER	SDAD. GENERAL AGUAS DE BARCELONA, S.A.	AGS
2	FOOD, BEVERAGES & TOBACCO	EL AGUILA, S.A. (FABR. DE CERVEZAS Y MALTA).	AGI
3	FOOD, BEVERAGES & TOBACCO	SDAD. GENERAL AZUCARERA DE ESPAÑA, S.A.	AZU
4	FOOD, BEVERAGES & TOBACCO	BODEGAS Y BEBIDAS, S.A.	BYB
5	FOOD, BEVERAGES & TOBACCO	COMPOFRIO ALIMENTACION, S.A.	CPF
6	FOOD, BEVERAGES & TOBACCO	EBRO AGRICOLAS, COMPAÑIA DE ALIMENTACION	EBA
7	FOOD, BEVERAGES & TOBACCO	KOIPE, S.A.	KOI
8	FOOD, BEVERAGES & TOBACCO	PULEVA, S.A.	PUL
9	FOOD, BEVERAGES & TOBACCO	TABACALERA, S.A.	TAB
10	FOOD, BEVERAGES & TOBACCO	VISCOFAN, S.A.	VIS
11	PARKING & HIGHWAYS	AUTOPISTAS CONCESIONARIA ESPAÑOLA, S.A.	ACE
12	PARKING & HIGHWAYS	AUTOPISTAS DEL MARE NOSTRUM, S.A.	AUM
13	PARKING & HIGHWAYS	EUROPISTAS CONCESIONARIA ESPAÑOLA, S.A.	EUR
14	PARKING & HIGHWAYS	IBERICA DE AUTOPISTAS, S.A. (IBERPISTAS)	IBP
15	AUTO & PARTS	CITROEN HISPANIA, S.A.	CIT
16	BANKS	BANCO DE ALICANTE	ALI
17	BANKS	BANCO DE ANDALUCIA, S.A.	AND
18	BANKS	BANCO ATLANTICO, S.A.	ATL
19	BANKS	BANCO BILBAO VIZCAYA	BBV
20	BANKS	BANCO CENTRAL HISPANO AMERICANO.	BCH
21	BANKS	BANKINTER, S.A.	BKT
22	BANKS	BANCO ESPAÑOL DE CREDITO, S.A.	BTO
23	BANKS	BANCO DE CASTILLA, S.A.	CAS
24	BANKS	BANCO DE CREDITO BALEAR S.A.	CBL
25	BANKS	BANCO DE GALICIA, S.A.	GAL
26	BANKS	BANCO GUIPUZCOANO, S.A.	GUI
27	BANKS	BANCO HERRERO, S.A.	HRR
28	BANKS	BANCO PASTOR, S.A.	PAS
29	BANKS	BANCO POPULAR ESPAÑOL, S.A.	POP
30	BANKS	BANCO SANTANDER, S.A.	SAN
31	BANKS	BANCO DE VASCONIA, S.A.	VAS
32	BANKS	BANCO ZARAGOZANO, S.A.	ZRG
33	PORTFOLIO INVESTMENT	GRUPO PICKING PACK, S.A.	GHS
34	BUILDING MATERIALS	CRISTALERIA ESPAÑOLA, S.A.	CRI
35	BUILDING MATERIALS	FINANCIERA Y MINERA, S.A.	FYM
36	BUILDING MATERIALS	HORNOS IBERICOS ALBA. (HISALBA)	HSB
37	BUILDING MATERIALS	UNILAND CEMENTERA S.A.	UND
38	BUILDING MATERIALS	URALITA, S.A.	URA
39	BUILDING MATERIALS	PORTLAND VALDERRIVAS, S.A.	VDR
40	GENERAL RETAILERS	FINANZAUTO, S.A.	FNZ
41	GENERAL RETAILERS	PRYCA S.A.	PRY
42	TELECOM SERVICES	TELEFONICA DE ESPAÑA, S.A.	TEF
43	CONSTRUCTION	AGROMAN, S.A., EMPRESA CONSTRUCTORA.	AGR
44	CONSTRUCTION	DRAGADOS Y CONSTRUCCIONES, S.A.	DRC
45	CONSTRUCTION	HUARTE, S.A.	HHU
46	CONSTRUCTION	CONSTRUCCIONES LAIN S.A.	LAI
47	CONSTRUCTION	GRAL. OBRAS Y CONSTR. OBRASCON S.A.	OBR

(continued)

Table 9.1 (continued)

N	SECTOR	COMPANY	CODE
48	ELECTRICITY & GAS DISTRIBUTION	HIDROELECTRICA DEL CANTABRICO, S.A.	CAN
49	ELECTRICITY & GAS DISTRIBUTION	ENDESA, S.A.	ELE
50	ELECTRICITY & GAS DISTRIBUTION	EMPRESA NAC. HIDROELECTRICA RIBAGORZANA	ENH
51	ELECTRICITY & GAS DISTRIBUTION	ELECTRICAS REUNIDAS DE ZARAGOZA, S.A.	ERZ
52	ELECTRICITY & GAS DISTRIBUTION	FUERZAS ELECTRICAS DE CATALUÑA, S.A. (FECSA)	FEC
53	ELECTRICITY & GAS DISTRIBUTION	GAS Y ELECTRICIDAD, S.A.	GES
54	ELECTRICITY & GAS DISTRIBUTION	IBERDROLA, S.A.	IBE
55	ELECTRICITY & GAS DISTRIBUTION	SALTOS DEL NANSA, S.A.	NAN
56	ELECTRICITY & GAS DISTRIBUTION	COMPAÑIA SEVILLANA DE ELECTRICIDAD S.A.	SEV
57	ELECTRICITY & GAS DISTRIBUTION	UNION ELECTRICA-FENOSA, S.A.	UNF
58	ELECTRICITY & GAS DISTRIBUTION	ELECTRA DE VIESGO, S.A.	VGO
59	HOLDING	CORPORACION FINANCIERA ALBA, S.A.	ALB
60	HOLDING	CORPORACION FINANCIERA REUNIDA, S.A.	CFR
61	HOLDING	GRUPO FOSFORERA S.A.	FFR
62	HOLDING	CORPORACION IND. FINANCIERA DE BANESTO.	LCB
63	REAL ESTATE	BAMI, S.A. INMOBILIARIA DE CONSTRUCCIONES.	BAM
64	REAL ESTATE	FILO, S.A.	FIL
65	REAL ESTATE	INMOBILIARIA ZABALBURU, S.A.	IZB
66	REAL ESTATE	INMOBILIARIA METROPOL. VASCO CENTRAL. S.A.	MVC
67	REAL ESTATE	PRIMA INMOBILIARIA S.A.	PIN
68	REAL ESTATE	SOTOGRANDE S.A.	STG
69	REAL ESTATE	URBANIZACIONES Y TRANSPORTES, S.A. (URBAS)	UBS
70	REAL ESTATE	INMOBILIARIA URBIS, S.A.	URB
71	REAL ESTATE	VALLEHERMOSO, S.A.	VAL
72	REAL ESTATE	INBESOS, S.A.	BES
73	MACHINERY	AMPER, S.A.	AMP
74	MACHINERY	AZKOYEN S.A.	AZK
75	MACHINERY	RUCCIONES Y AUXILIAR DE FERROCARRIL MAQUINARIA.	CAF
76	MACHINERY	DIMETAL S.A.	DMT
77	MACHINERY	GRUPO DURO FELGUERA, S.A.	MDF
78	MACHINERY	NICOLAS CORREA S.A.	NEA
79	MACHINERY	RADIOTRONICA S.A.	RAD
80	MACHINERY	SDA. ESPAÑOLA DEL ACUMULADOR TUDOR, S.A.	TUD
81	MACHINERY	ZARDOYA OTIS, S.A.	ZOT
82	STEEL & MINING	ACERINOX, S.A.	ACX
83	STEEL & MINING	ASTURIANA DEL ZINC S.A.	AZC
84	STEEL & MINING	NUEVA MONTAÑA DE QUIJANO, S.A.	NMQ
85	STEEL & MINING	ESPAÑOLA DEL ZINC, S.A.	ZNC
86	DIVS. INDUSTRIALS	TAVEX ALGODONERA SAN ANTONIO, S.A.	ASA
87	DIVS. INDUSTRIALS	SEDA DE BARCELONA, S.A. (LA).	SED
88	DIVS. INDUSTRIALS	VIDRALA S.A.	VID
89	FORESTRY & PAPER	EUROP. PAPER A. PACKAGINS INVEST.	EPC
90	FORESTRY & PAPER	SARRIO S.A.	SAR
91	FORESTRY & PAPER	SDAD. NAC. IND. APL. CEL. ESPAÑOLA, S.A.	SNC
92	FORESTRY & PAPER	TABLEROS DE FIBRAS, S.A. (TAFISA)	TFI
93	FORESTRY & PAPER	UNIPAPEL, S.A.	UPL

(continued)

Table 9.1 (continued)

N	SECTOR	COMPANY	CODE
94	OIL	CIA. ESPAÑOLA DE PETROLEOS, S.A. (CEPSA)	CEP
95	OIL	REPSOL S.A.	REP
96	CHEMICALS	ENERGIA E INDUSTRIAS ARAGONESAS, S.A.	ARA
97	CHEMICALS	SAD. ESPAÑOLA DE CARBUROS METALICOS, S.A.	CAR
98	CHEMICALS	ERCROS S.A.	ECR
99	SERVICES	GRUPO ANAYA S.A.	ANY
100	SERVICES	MARCO IBERICA DE DISTRIBUCIONES S.A.	MID
101	SERVICES	PROSEGUR S.A., CIA. DE SEGURIDAD.	PSG
102	INVESTMENT COMPANIES	CIA. GENERAL DE INVERSIONES, S.A.S.I.M.	CGI
103	METALS	GLOBAL STEEL WIRE, S.A.	GSW
104	METALS	TUBACEX, S.A.	TUB

Table 9.2 Monthly observed return on 1 euro invested in "El Aguila SA" (Madrid Exchange, 1992–1997)

	1992 (%)	1993 (%)	1994 (%)	1995 (%)	1996 (%)	1997 (%)
January	10.64	2.34	12.75	−9.63	−12.06	7.52
February	−0.29	1.95	−3.11	−1.44	1.34	3.88
March	25.46	14.53	−1.50	−14.23	10.28	−5.03
April	−4.46	2.08	3.51	−3.51	13.96	6.77
May	−0.16	2.03	11.99	−1.67	−4.11	13.35
June	−12.34	−5.56	−11.77	−4.34	10.93	−2.84
July	−36.46	2.77	−5.94	−2.32	−7.63	11.68
August	−11.95	43.02	−12.72	−0.29	−2.44	−8.83
September	−2.23	−14.72	−1.40	1.31	−7.50	−2.74
October	17.87	0.66	−20.35	−7.00	−6.67	−13.80
November	5.59	17.95	18.45	−13.56	8.09	1.63
December	−5.83	−2.30	−14.97	−15.26	−4.52	−2.55

Information on returns is elicited from the Spanish stock agency's yearly books for cash flows (dividends, rights offering) while capital gains are monthly computed from daily closing prices appearing at http://www.megabolsa.com. Both dividends and rights offering are placed on the day of payment (in the case of dividends) or exercise, in the case of rights offering. To obtain unbiased returns, the capital gains were computed by regression analysis of daily prices on time. In this way, random price impacts over each monthly period are mitigated. For each stock, the monthly returns are given by the standard expression 'ending value minus beginning value'. After normalizing by the beginning value, this expression turns into:

$$\text{normalized return} = \frac{\text{ending value} + \text{cash flow}}{\text{beginnig value}} - 1$$

In Table 9.2, an illustrative real case is shown, the normalized returns on "El Aguila SA" over the period 1992–1997. As noted, each return is specified in percentage terms on the beginning value.

Mean values, variances and covariances are computed by using a spreadsheet. A fragment of the covariance matrix is shown in Table 9.3, as the whole matrix including 104 rows × 104 columns is obviously impossible to insert here.

From the above information, twelve efficient frontiers are derived by Markowitz's mean-variance model (9.1)–(9.3), which involves solving a quadratic program by Lingo or Matlab software. This program is subject to diversification constraints at 5 % level according to the Spanish norms. About 25 efficient portfolios are determined on each frontier, their expected return and variance being recorded in Table 9.4.

In Fig. 9.2 the January, July, and December (1997) mean-variance frontiers are plotted. Notice that July and December frontiers almost coincide. We see that the July frontier starts at point *A* (0.005; 0.003102), then it goes down and reaches its minimum variance value at point *B* (0.015; 0.000913), then going up to reach the maximum variance value at point *C* (0.13; 0.055267). Therefore, the greatest expected return is associated with the maximum variance at point *C*. Arc *AB* is the inefficient bullet arc (Reilly 1985, p. 230), which should be removed from the true frontier. This standard shape is maintained by the other monthly frontiers, apart from slights discontinuities.

Each frontier above computed in year 1997 is suitable for a given month (e.g., January), just the month in which the investor wants to create his buy & hold portfolio. Remember that buy & hold is a strategy in which the investor maintains his portfolio without changes over the investment period, namely, there is no trading. This strategy is a departure from active management policy, in which the portfolio is changed every month by computing new efficient frontiers with further information coming from recent months. Henceforth, the case study of the Madrid Exchange is developed to approximate the utility optimum for different buy & hold investors on the January mean-variance efficient frontier.

9.3 First Stage: Basic Statements

Some preliminary matters should be pointed out. Variance measures risk as "the more the worse" variable while expected return (just measured by the mean) behaves, as "more is better". However, utility is typically viewed as a trade-off between profitability and safety. The portfolio variance which behaves "the more the worst" should be converted into safety, which behaves "the more the better". Mean and variance will be normalised over the 0–1 range, which allows us to make meaningful comparisons in the utility trade-off. Both the expected return and variance are normalized by the following equations:

$$\theta_1 = \frac{E - E^*}{E^* - E_*} \tag{9.15}$$

$$\theta_1 = \frac{V_* - V}{V^* - V_*} \tag{9.16}$$

where,

θ_1 = index of profitability, ranging over 0–1.
θ_2 = index of safety, ranging over 0–1.
E = portfolio expected return.
V = portfolio variance.
E^* = CP ideal or anchor value for expected returns, namely, $E^* = E_{max}$.
E_* = CP anti-ideal or nadir value for expected returns, namely, $E_* = E_{min}$.
V^* = CP ideal or anchor value for variance. This is the smallest variance V_{min}.
V_* = CP anti-ideal or nadir value for variance. This is the largest variance V_{maX}.

Therefore, the normalized ideal point is $\theta_1{}^* = 1, \theta_2{}^* = 1$. In Table 9.5, the normalized indexes (θ_1, θ_2) of 18 portfolios on the January efficient frontier (once the inefficient bullet arc has been removed) are shown, as computed from Eqs. (9.15)–(9.16).

In Fig. 9.3 the January normalized efficient frontier is plotted.

As we leave point D (at which safety and profitability reach their maximum and minimum values respectively), curve DL_1A goes down toward point A, at which safety and profitability reach their minimum and maximum values respectively. This normalized frontier is concave down on the interval OA. Normalized ideal $I(1, 1)$ is the point at which the vertical line through A and the horizontal line through D intersect.

Preferences for profitability and safety substantially change from one investor to another, and therefore the empirical search for them should be undertaken by the analyst in each particular scenario. To elicit the preference weights, we use the following questionnaire: "Imagine you have a well-balanced profitability-safety portfolio. If you want to increase profitability, which percentage of safety are you willing to lose at most for increasing profitability by 10 %. In contrast, if you want to increase safety, which percentage of profitability are you willing to lose at most for increasing safety by 10 %". In this dialogue, different answers can be given. For example: "I am willing to lose around 12 % of safety". This case leads to $r_0 = w_1/w_2 = 1.2$.

9.4 Second Stage: Bounding the Investor's Utility Optimum

The analyst should approximate the investor's utility optimum by bounding its position on the efficient frontier. For this purpose, in Fig. 9.4 the points which appear on the efficient curve are obtained by optimizing linear utility functions for different preferences. More precisely, they are CP solutions with metric 1, given by:

$$\min\,(r_0(1 - \theta_1) + \theta_2) = \max\,(r_0\theta_1 + \theta_2) \tag{9.17}$$

subject to the normalized efficient frontier. In Eq. (9.17), parameter $r_0 = w_1/w_2$ is the preference weight ratio. In the special case $r_0 = 1$ of equal weighting, we obtain

Table 9.3 Covariance matrix from 104 companies monthly returns (Madrid Exchange, from January 1992 to December 1996) (Fragment)

	1	2	3	4	5	6	7	8	9	10
1	0.008118	0.003804	0.000178	0.000999	0.003402	0.005396	−0.000037	0.004850	0.006122	0.007104
2	0.003804	0.014513	0.002071	−0.000225	0.003998	0.003091	0.000963	0.005002	0.004641	0.008957
3	0.000178	0.002071	0.006206	0.002584	0.002016	0.001530	0.000649	0.000982	0.000089	0.000277
4	0.000999	−0.000225	0.002584	0.007699	0.001529	0.001920	−0.000377	0.000336	0.000662	−0.000129
5	0.003402	0.003998	0.002016	0.001529	0.010952	0.003869	0.001853	0.004731	0.002009	0.003868
6	0.005396	0.003091	0.001530	0.001920	0.003869	0.009185	0.000560	0.005480	0.006324	0.005045
7	−0.000037	0.000963	0.000649	−0.000377	0.001853	0.000560	0.002916	0.000029	−0.000181	0.001129
8	0.004850	0.005002	0.000982	0.000336	0.004731	0.005480	0.000029	0.018439	0.006465	0.004753
9	0.006122	0.004641	0.000089	0.000662	0.002009	0.006324	−0.000181	0.006465	0.011139	0.006386
10	0.007104	0.008957	0.000277	−0.000129	0.003868	0.005045	0.001129	0.004753	0.006386	0.021375

Table 9.4 Mean-variance efficient frontiers (1997) from 104 companies monthly returns (Madrid Exchange, 1992–1996)

(1)	(2)											
	January	February	March	April	May	June	July	August	September	October	November	December
0.000	0.0012	0.0019	0.0020	0.0022	0.0023	0.0048	–	–	–	–	–	–
0.005	0.0008	0.0010	0.0010	0.0010	0.0011	0.0017	0.0031	–	–	–	–	–
0.010	0.0006	0.0007	0.0007	0.0008	0.0008	0.0010	0.0013	0.0014	0.0015	0.0020	0.0015	0.0018
0.015	0.0006	0.0007	0.0007	0.0007	0.0006	0.0009	0.0009	0.0009	0.0009	0.0009	0.0010	0.0010
0.020	0.0007	0.0007	0.0007	0.0006	0.0007	0.0008	0.0009	0.0009	0.0008	0.0009	0.0008	0.0008
0.025	0.0008	0.0008	0.0009	0.0008	0.0008	0.0009	0.0013	0.0008	0.0008	0.0008	0.0008	0.0009
0.030	0.0012	0.0011	0.0011	0.0010	0.0010	0.0010	0.0010	0.0009	0.0010	0.0009	0.0009	0.0010
0.035	0.0014	0.0014	0.0014	0.0013	0.0013	0.0014	0.0021	0.0011	0.0011	0.0010	0.0011	0.0011
0.040	0.0019	0.0021	0.0019	0.0017	0.0017	0.0017	0.0016	0.0015	0.0014	0.0013	0.0014	0.0014
0.045	0.0025	0.0025	0.0024	0.0023	0.0023	0.0024	0.0019	0.0017	0.0016	0.0017	0.0017	0.0018
0.050	0.0031	0.0032	0.0032	0.0033	0.0039	0.0028	0.0024	0.0024	0.0021	0.0021	0.0022	0.0022
0.055	0.0040	0.0040	0.0041	0.0038	0.0036	0.0035	0.0030	0.0029	0.0027	0.0024	0.0030	0.0028
0.060	0.0051	0.0051	0.0051	0.0048	0.0046	0.0045	0.0043	0.0036	0.0035	0.0030	0.0037	0.0036
0.065	0.0065	0.0065	0.0066	0.0061	0.0058	0.0056	0.0054	0.0045	0.0043	0.0038	0.0047	0.0046
0.070	0.0082	0.0081	0.0080	0.0077	0.0073	0.0076	0.0060	0.0058	0.0058	0.0048	0.0059	0.0057

(continued)

Table 9.4 (continued)

(1)	(2)											
	January	February	March	April	May	June	July	August	September	October	November	December
0.075	0.0102	0.0101	0.0100	0.0096	0.0091	0.0086	0.0074	0.0070	0.0067	0.0059	0.0073	0.0071
0.080	0.0128	0.0125	0.0123	0.0118	0.0113	0.0106	0.0092	0.0087	0.0083	0.0074	0.0090	0.0087
0.085	0.0159	0.0155	0.0152	0.0146	0.0141	0.0130	0.0113	0.0108	0.0102	0.0090	0.0111	0.0106
0.090	0.0200	0.0190	0.0186	0.0179	0.0173	0.0158	0.0139	0.0132	0.0125	0.0112	0.0139	0.0131
0.095	0.0266	0.0233	0.0225	0.0218	0.0212	0.0191	0.0169	0.0171	0.0154	0.0137	0.0168	0.0161
0.100	0.0358	0.0276	0.0270	0.0262	0.0256	0.0229	0.0205	0.0197	0.0188	0.0172	0.0204	0.0197
0.105	–	0.0331	0.0323	0.0313	0.0306	0.0272	0.0244	0.0238	0.0226	0.0204	0.0245	0.0237
0.110	–	0.0410	0.0399	0.0384	0.0375	0.0320	0.0290	0.0283	0.0270	0.0246	0.0293	0.0283
0.115	–	–	–	–	0.0470	0.0374	0.0339	0.0334	0.0319	0.0293	0.0344	0.0334
0.120	–	–	–	–	–	0.0441	0.0396	0.0390	0.0373	0.0344	0.0401	0.0391
0.125	–	–	–	–	–	0.0522	0.0467	0.0458	0.0437	0.0402	0.0470	0.0457
0.130	–	–	–	–	–	0.0623	0.0553	0.0540	0.0606	0.0473	0.0550	0.0537
0.135	–	–	–	–	–	–	–	–	–	0.0557	–	–

Notes: (1) Target or aspiration level e_0 of expected return, which is a parameter ranging between 0 and 0.135; (2) Minimum variance obtained by the Markowitz E-V model for every month of year 1997.

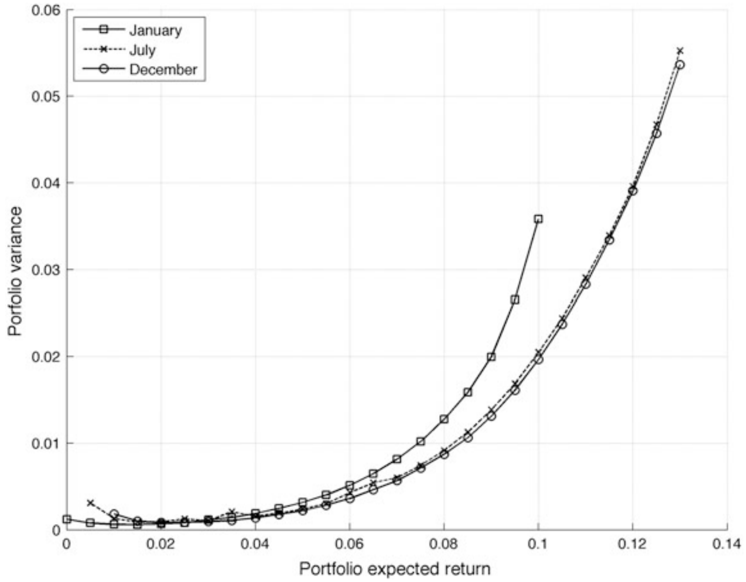

Fig. 9.2 Mean-variance efficient frontiers (January, July, and December, 1997) on the Madrid Exchange

point L_1 on the frontier. Let us determine this point geometrically. Consider the family of lines $\theta_1 + \theta_2 = \lambda$, which are parallel to line AD because $OA = OD = 1$. As noted, point L_1 maximizes λ on the frontier. Therefore, L_1 is the tangency point of parallel lines to AD on the curve.

Metric with r_0 weighting leads to points whose positions on the frontier curve are determined by the infinity norm, namely:

$$r_0(1 - \theta_1) = (1 - \theta_2) \tag{9.18}$$

In the special case $r_0 = 1$ of equal weighting, which corresponds to frontier point L_∞, Eq. (9.18) yields $\theta_1 = \theta_2$. This is the ray crossing the map from the origin O to the ideal point $I(1, 1)$. Therefore, it is the frontier point at which this ray intercepts the curve. If the curve is slightly asymmetric with respect to bisector OI, then points L_1 and L_∞ lie close to one another (see Fig. 9.4). If the curve is perfectly symmetric, then both points coincide at the intersection of ray OI with the curve.

Denote by S a conservative profile of investors who prefer safety to profitability. They are known as safety seekers or conservative investors, and are characterized by $r_0 < 1$. Denote by P an aggressive profile of investors who prefer profitability to safety. They are called profitability seekers or aggressive investors, and are characterized by $r_0 > 1$.

We propose the following scale:

– S investors of extreme intensity. Reference value $r_0 = 0.25$.
– S investors of very strong intensity. Reference value $r_0 = 0.35$.

Table 9.5 January normalized efficient frontier (Madrid Exchange, 1997)

(1)	(2)	(3)	(4)	(5)
1	0	0.0012	–	–
2	0.005	0.0008	–	–
3	0.01	0.0006	–	–
4	0.015	0.0006	0	1
5	0.02	0.0007	0.0588	0.9981
6	0.025	0.0008	0.1176	0.9942
7	0.03	0.0012	0.1765	0.9841
8	0.035	0.0014	0.2353	0.977
9	0.04	0.0019	0.2941	0.9639
10	0.045	0.0025	0.3529	0.9471
11	0.05	0.0031	0.4118	0.928
12	0.055	0.004	0.4706	0.9032
13	0.06	0.0051	0.5294	0.8717
14	0.065	0.0065	0.5882	0.8328
15	0.07	0.0082	0.6471	0.7858
16	0.075	0.0102	0.7059	0.7278
17	0.08	0.0128	0.7647	0.6544
18	0.085	0.0159	0.8235	0.5661
19	0.09	0.02	0.8824	0.4501
20	0.095	0.0266	0.9412	0.2629
21	0.1	0.0358	1	0

(1) efficient portfolio code; (2) efficient portfolio mean value; (3) efficient portfolio variance; (4) Profitability normalized index (); (5) Safety normalized index ( )

- S investors of strong intensity. Reference value $r_0 = 0.45$.
- S investors of moderate intensity. Reference value $r_0 = 0.6$.
- S investors of low intensity. Reference value $r_0 = 0.84$.
- Standard investors, who are neither safety seekers nor profitability seekers. $r_0 = 1$.
- P investors of low intensity. Reference value $r_0 = 1.25$.
- P investors of moderate intensity. Reference value $r_0 = 1.75$.
- P investors of strong intensity. Reference value $r_0 = 2.25$.
- P investor s of very strong intensity. Reference value $r_0 = 2.75$.
- P investor of extreme intensity: $r_0 > 3$. Reference value $r_0 = 4$.

As a numerical example, we develop some cases of investors who pursue a buy & hold strategy.

Case 1. An investor P of moderate intensity with $r_0 = 1.7$.
Case 2. A standard investor $r_0 = 1$.
Case 3. An investor S of extreme intensity with $r_0 = 0.3$.

Fig. 9.3 January normalized efficient frontier (Madrid Exchange, 1997): Curve shape and the ideal point

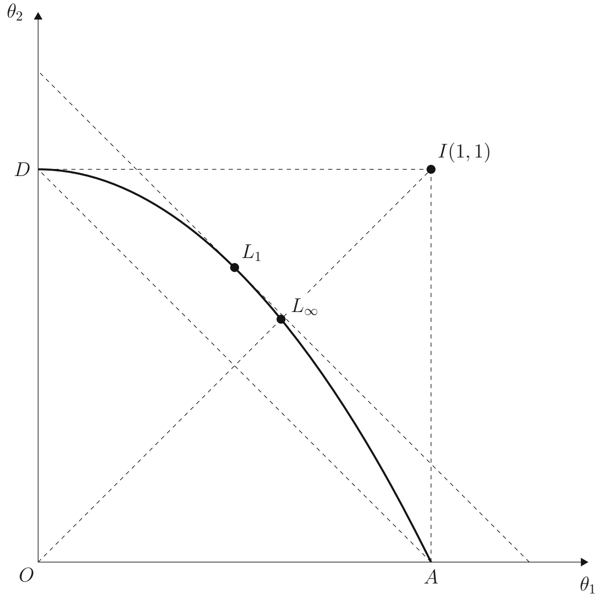

Fig. 9.4 January normalized efficient frontier (Madrid Exchange, 1997): bounds for different investor profiles

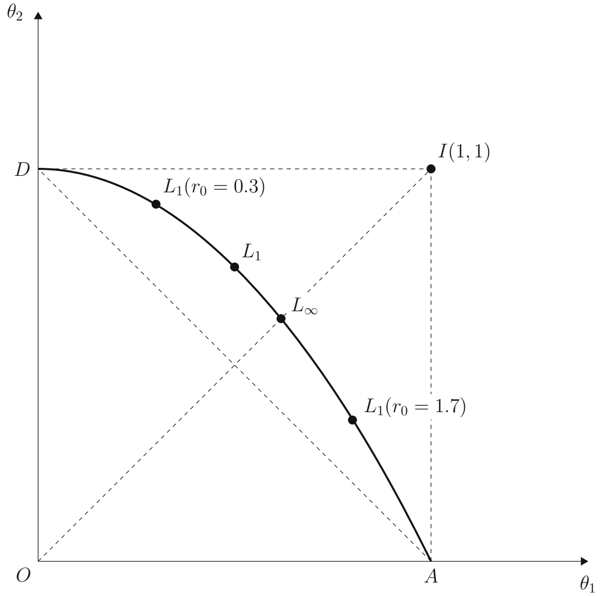

Table 9.6 refers to the January efficient frontier, whose portfolios are maintained by the investor over the whole year 1997 as a buy & hold strategy. This table is organized as follows.

Table 9.6 Bounds on the investor's utility optimum on the efficient frontier (Madrid Exchange, 1997)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
4	0.0000	1.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000
5	0.0588	0.9981	1.0981	0.1002	1.0569	0.0589	1.0157	0.0177
6	0.1176	0.9942	1.1941	0.2011	1.1118	0.1183	1.0295	0.0355
7	0.1765	0.9841	1.2842	0.3049	1.1606	0.1794	1.0371	0.0538
8	0.2353	0.9770	1.3770	0.4094	1.2123	0.2408	1.0476	0.0723
9	0.2941	0.9639	1.4639	0.5187	1.2580	0.3051	1.0521	**0.0915**
10	0.3529	0.9471	1.5470	0.6334	1.3000	0.3726	**1.0530**	0.1118
11	0.4118	0.9280	1.6281	0.7544	1.3398	0.4438	1.0515	0.1331
12	0.4706	0.9032	1.7032	0.8858	1.3738	0.5210	1.0444	0.1563
13	0.5294	0.8717	1.7717	**1.0324**	1.4011	0.6073	1.0305	0.1822
14	0.5882	0.8328	1.8327	1.2007	1.4210	0.7063	1.0093	0.2119
15	0.6471	0.7858	1.8859	1.3999	1.4329	0.8235	0.9799	0.2470
16	0.7059	0.7278	1.9278	1.6488	**1.4337**	**0.9699**	0.9396	0.2910
17	0.7647	0.6544	1.9544	1.9865	1.4191	1.1686	0.8838	0.3506
18	0.8235	0.5661	**1.9661**	2.4730	1.3896	1.4547	0.8132	0.4364
19	0.8824	0.4501	1.9502	3.3328	1.3325	1.9605	0.7148	0.5881
20	0.9412	0.2629	1.8629	6.0861	1.2041	3.5801	0.5453	1.0740
21	1.0000	0.0000	1.7000	–	1.0000	–	0.3000	–

(1) efficient portfolio code; (2) efficient portfolio normalized mean value (θ_1); (3) efficient portfolio normalized safety (θ_2); (4) 1.7 $\theta_1 + \theta_2$ value; (5) 1.7 θ_1/θ_2 ratio (6) ($\theta_1 + \theta_2$) value; (7) θ_1/θ_2 ratio; (8) 0.3 $\theta_1 + \theta_2$ value; (9) 0.3 θ_1/θ_2 ratio.

Column 1. Code of every efficient portfolio from Table 9.5, after removing bullet shape portfolios 1–3.
Column 2. Profitability index of each efficient portfolio after normalizing between 0 and 1.
Column 3. Safety index of each efficient portfolio after normalizing between 0 and 1.
Column 4. This column provides the maximum value of ($\theta_1 + \theta_2$) which is equal to 1.9661 as highlighted in bold. From Eq. (9.17), this maximum leads to portfolio number 18, which is the $L_1(r_0) = 1.7$ bound.
Column 5. This column gives us the row in which $\frac{1.7\theta_1}{\theta_2} \simeq 1$, namely, $1.7\theta_1 \simeq \theta_2$. From Eq. (9.18), this equality leads to portfolio number 13, which is the bound $L_\infty(r_0) = 1.7$.
Column 6. Here, an analogous process to column 4 leads to portfolio number 16 as the L_1 bound.
Column 7. An analogous process to column 5 yields portfolio number 16 as the L_∞ bound.
Column 8. The process is analogous to column 4, leading to portfolio number 10, which is the $L_1(r_0) = 0.3$ bound.
Column 9. The process is analogous to column 5, leading to portfolio number 9, as the $L_\infty(r_0) = 0.3$ bound.

In Fig. 9.4, check that point $L_1(r_0) = 0.3$ which represents an example of S investor, lies between L_1 and the highest point D on the frontier, while $L_1(r_0) = 1.7$, which represents an example of P investor, lies between L_∞ and the lowest point A on the frontier. Points $L_\infty(r_0) = 0.3$ and $L_\infty(r_0) = 1.7$ are not graphed in this figure. As readers know, the utility optimum for investors with $r_0 = 1.7$ is bounded between $L_1(r_0) = 1.7$ and $L_\infty(r_0) = 1.7$. Analogously, for investors with $r_0 = 0.3$. If the decision-maker is a standard investor, then the utility optimum is bounded between L_1 and L_∞.

Consider bounds $L_1(r_0)$ and $L_\infty(r_0)$ for an investor whose preferences for the criteria are given by $r_0 = w_1/w_2$. Suppose the case in which only one portfolio lies between these bounds. In this case, this unique portfolio is the best investment. On the contrary, suppose there are more than one portfolio between. Then, a problem arises with the choice among the several alternatives involved. To solve it, remember Yu's theorem (see Sect. 9.1). From this theorem, every CP solution for any p metric lies between $L_1(r_0)$ and $L_\infty(r_0)$. If the investor's risk aversion is very high/very low, then the investor will prefer a portfolio close to $L_\infty(r_0)/L_1(r_0)$, respectively. Generally speaking, the higher the investor's risk aversion the closer the portfolio to the $L_\infty(r_0)$ bound while the lower the risk aversion the closer the portfolio to the $L_1(r_0)$ bound.

Conclusions

We have addressed a satisfying CP solution to portfolio choice, which appears as a sensible alternative to traditional approaches. With this proposal, we offer an alternative framework to the $Eu(R)$ maximization problem for the purpose of selecting portfolios. This approach derives from linkages between utility functions under complete information, Yu's compromise set, and certain biased sets of portfolios on the efficient frontier. These linkages rely on recent theorems in multicriteria literature, which allow us to approximate the investor's utility optimum between bounds which are determined either by linear programming or graphic techniques.

To illustrate the methodology, which can be rooted in the classic financial background, a retrospective case of portfolio selection in a European Stock Exchange is developed. We have faced a large-scale problem of two stages: efficient frontiers and utility bounds. Information on returns was obtained from the Spanish stock agency's yearly book in order to obtain normalized returns. By starting with an opportunity set consisting in a universe of more than 100 stocks we obtain the mean values, variances and covariances. The path to deriving the efficient frontiers and to bounding the set of portfolios closest to the investor's utility optimum has been developed through numerical tables and figures for several types of investor profiles: conservative, standard and aggressive.

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Chapter 10
Ethically Constrained Portfolio Selection of Funds by CP Modelling: A Real World Environmental Case

Ana Garcia-Bernabeu, Blanca Pérez-Gladish, and Adolfo Hilario

Abstract In CP models to select ethical financial portfolios of securities, the ethical component can be articulated either by introducing SRI objectives or by introducing SRI constraints. None of these procedures is free of drawbacks. To place SRI objectives seems appealing because trade-offs can be stated between SRI goals and financial goals. However, to build these trade-offs requires articulating investor's preference weights for SRI and financial objectives. To elicit these weights is quite impossible in mutual funds because preferences differ from one investor to another in the fund. We propose a multicriteria portfolio selection model for mutual funds based on CP which takes into account both, a financial and a non-financial dimension taking into account the subjective and individual preferences of an individual investor under two different scenarios: a low social responsibility degree and a high social responsibility degree scenario. An real case study is performed on 110 large cap equity mutual funds.

10.1 Motivating the Problem

Many institutional and individual investors are willing to select their portfolios from opportunities sets of funds rather than from opportunity sets of stocks. To invest in funds is somewhat advantageous for some reasons. First, each fund comes from a previous selection in which the universe of assets has been screened and inferior

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financial quality stocks have been removed. Second, each fund is a diversified portfolio itself, so that the investor is less concerned with diversification. Third, investors in funds are less concerned with liquidity than investors in stocks, as shareholders can cancel their shares in the fund at any moment, at market prices.

Socially responsible investment (SRI) is widely extended as an ethical global movement whose followers decide to invest, not only from financial motivation but also from environmental and social motivation. Therefore, companies that perform sustainable environmental and social policies are preferred to invest by these followers. In some cases they impose a veto against anti-ethical investment and sometime they introduce an environmental constraint into their portfolio selection models. As reliable information on ethical performance is available for funds rather than for stocks, the relevant SRI problem is how to select portfolios of funds. Ethical portfolio selection with previous screening of the opportunity set which is equivalent to veto, can be viewed as somewhat inconvenient as funds of good financial quality can be abruptly removed from the opportunity set by the screening (Knoll 2002; Michelson et al. 2004). In any case, there is an ongoing issue that transparency and credibility of companies are sometimes difficult to discern (Koellner et al. 2005; Schrader 2006; Chatterji et al. 2009).

Few works have analyzed the effect on the efficient frontiers of including socially responsible concerns. Drut (2010) introduces a social responsibility threshold in the traditional (Markowitz 1952) portfolio selection setting by including in the mean-variance optimization social responsibility linear constraints. This allows the computation of the cost derived from the reduction of the investment universe after screening. He obtains four SR-efficient frontiers depending on the level of the SR threshold: (a) identical to the non-SR frontier (i.e. no cost), (b) only the left portion is penalized (i.e. a cost for high-risk-aversion investors only), (c) only the right portion is penalized (i.e. a cost for low-risk aversion investors only) and (d) the whole frontier is penalized (i.e. a positive cost for all the investors). Hirschberger et al. (2012) calculate a three-dimensional efficient frontier including a socially responsible objective together with the classical financial ones.

Mutual Funds' social performance measurement has been addressed by several authors. However, most of these works use a binary variable for two social responsible categories (social responsible/non-social responsible funds) relying on mutual funds' self-classification into one of those categories (see for example, Basso and Funari 2003). Very few studies can be found considering different degrees of social responsibility and as screens are the most important tool for arriving at SRI authors rely on this proxy as an indicator of mutual funds social performance. Basso and Funari (2005, 2007, 2010), Scholtens (2007), Barnett and Salomon (2006), Renneboog et al. (2008), Lee et al. (2010), Jegourel and Maveyraud (2010), and Pérez-Gladish et al. (2013) are some of the works proposing screening intensity as a proxy of mutual funds' social performance.

Scoring of mutual funds taking into account socially responsible criteria has an important practical relevance in portfolio selection especially nowadays, given the causes of the 2008 financial crisis, when these concerns became even more relevant for investors. Portfolio Selection models including social and/or environmental criteria are rather in scarce (see Ballestero et al. 2012; Gupta et al. 2013; Barrachini 2004; Bilbao-Terol et al. 2012, 2013; Hallerbach et al. 2004; Hirschberger et al. 2012; Steuer et al. 2007; Dorfleitner et al. 2012) and in most of the cases social and/or environmental performance measurement relies on a crisp or precise real number reflecting the number of applied screens.

The social performance measures proposed in these works usually rely on the information provided by independent agencies as the Social Investment Forum(SIF) which bases their information on data directly provided by mutual funds' managers without checking transparency and accuracy of this information which in most of the cases is too imprecise. This chapter aims at the following objectives:

(i) To propose a CP portfolio selection model (Zeleny 1982; Yu 1985) from fund opportunities, oriented to SRI purposes. This requires introducing an environmental constraint in the space of profitability and safety criteria.
(ii) To develop an actual environmental case of ethically constrained portfolio selection from a wide opportunity set of funds by using the proposed CP model with empirical information provided by KLD Research & Analytics Inc. over the period 2000–2010.

There are a range of financial agents who are potentially interested in this kind of programs, such as fund managers, banks, ecologists, financial consultants and government officials.

10.2 The CP Model

Consider an opportunity set $F_i (i = 1, 2, \ldots, m)$ whose time series of weekly random returns over the recent past are known. Information on ethical (environmental) achievement over the recent past is available. Our purpose is to select an ethically constrained fund portfolio F of funds F_i for "buy and hold" policies. For this purpose a CP model is used with the following setting.

(a) A space of decision variables, where $X = (x_1, x_2, \ldots, x_n)$ is the ith portfolio weight, namely, the percentage of capital to be invested in fund F_i. Therefore, we have:

$$\sum_{i=1}^{n} x_i = 1; \quad x_i \geq 0 \quad \forall i \tag{10.1}$$

In the case of hedge fund investment involving leverage and short selling, constraints (10.1) do not hold.

(b) A space of criteria $r_j = (j = 1, 2, \ldots, n)$. In this chapter, only two criteria are considered, expected return E and risk, the latter being measured by standard deviation σ or variance σ^2. Therefore, we have:

$$E_F = \sum_{i=1}^{n} E_i x_i \tag{10.2}$$

where E_F is expected return of fund F, while E_i is expected return of fund F_i.

$$\sigma_F^2 = XVX^T \tag{10.3}$$

where,

σ_F^2 is the variance of fund F
V is the $n \times n$ covariance matrix of funds F_i
X^T is the transposed X vector

A needed step is to compute Markowitz's $E-V$ efficient frontier (Markowitz 1952) by Eqs. (9.1)–(9.3). After this step, profitability E and variance risk V should be converted into profitability-safety normalized indices by Eqs. (9.4)–(9.7).

(c) An ideal point, which is defined as the best in expected return and the best in safety, both targets (anchor values) being normalized with coordinates $\theta_1^* = \theta_2^* = 1$. As readers know, this ideal (utopian) is an infeasible point of reference to compare performances of funds F_i. The closer the fund to the ideal the better the fund performance. As explained in Sect. 9.1, the antiideal point or nadir values is $\theta_{1*} = \theta_{2*} = 0$, namely, the origin of coordinates (Ballestero and Romero 1996, 1998).

(d) A set of significant SRI constraints, given by:

$$\sum_{i=1}^{n} e_{ki} x_i \geq t_k; \quad k = 1, \ldots, h \tag{10.4}$$

From this setting, the CP model is stated as follows:

$$\min[w_1^p (1 - \theta_1)^p + w_2^p (1 - \theta_2)^p]^{1/p} \tag{10.5}$$

subject to constraints (10.4) and (10.1) together with the efficient frontier, which is obtained by Eqs. (9.1)–(9.3).

In objective function (10.5), symbols (w_1, w_2) are preference weights for expected return and safety, respectively, while p denotes the CP metric.

This model is solved for different values of metric p by Matlab or by another powerful optimization software tool. The higher the investor's risk aversion the higher the p metric. As to the metric choice see Ballestero (1997).

10.3 Actual Environmental Case

Our database is composed of both, conventional and socially responsible mutual funds. The set of socially responsible mutual funds (25 mutual funds) consists of all the large cap equity mutual funds which are members of the Social Investment Forum (SIF). For the conventional mutual funds our initial database, provided by Morningstar Ltd, consisted of 10,038 open end U.S. large cap equity mutual funds. We applied a filter to this database in order to obtain the set of funds with complete weekly return data from 8/22/2000 to 8/21/2010. This filter gave rise to a set of 1505 mutual funds. Our random sample consists of around 5 % of this last set of funds, i.e. 85 conventional U.S. large cap equity mutual funds with inception date prior to 22/08/2000 and complete weekly return data for the 10 year period.

From information provided by the mutual funds and available at the Social Investment Forum(SIF) website, we can observe how all the socially responsible mutual funds seek to invest in companies which derive some proportion of the revenues from the development of innovative products with environmental benefits; most of the funds invest in companies that have taken measures to reduce the contribution of their operations to global climate change; funds also seem to avoid investing in companies which produce hazardous waste. It is interesting to observe that no one of the funds explicitly mention to invest in companies that have demonstrated a superior commitment to management systems through ISO 14001 certification and other voluntary programs. Most of the issues of concern are related to climate change and clean technologies; development of innovative products with environment benefits; avoiding of investments in companies which have liabilities for hazardous waste.

All the studied socially responsible mutual funds invest in companies that have innovative hiring or other human resource programs for minorities. The 25 funds avoid investing in companies that have problems with human rights or directly support governments that systematically deny human rights. Most of the funds give also importance to investments in companies which have a good relationship with their unionized workforce. Most of the funds invest in companies with good corporate governance practices. The funds seek to invest in companies with a fair executive pay policy and with governance policies that promote independence, accountability and transparency.

All the funds exclude from their investments companies manufacturing alcohol beverages. Funds F18–F24 also avoid investing in companies that distribute alcohol or license their company or brand name to alcohol products. Almost all the funds restrict investment in companies involved in animal testing. Funds F20 and F21 explicitly recognizes that medical products are required to undergo animal testing in compliance with the FDA. All funds avoid investing in companies which derive revenues from the sale of conventional weapons systems and/or ammunition or earned money from the sale of nuclear weapons or weapons systems. All the funds avoid investing in companies which produce goods and/or provide services related with gambling and avoid investing in companies which manufacture tobacco products. The investor, based on his personal subjective preferences evaluates the social responsibility degree of each of the applied screens. He takes into account the type of screening, positive or negative (for example, for a particular investor negative screening could be more social responsible than positive screening) and the different issues screened (for example, for a particular investor human rights could be more social responsible than recycling). There are different proposals for the measurement of asset's social responsibility degree, as for example, the method proposed in Chap. 4. In order to measure the mutual funds Social Responsibility degree we will take into account 49 criteria (41 related with Social Responsible Investment Strategy and 8 criteria related to Quality of Information). Mutual funds' environmental responsibility is measured at the firm level (Corporate Social Performance of the firms invested in by the mutual fund) and then the resulting measures are aggregated taking into account the weight of each firm in the mutual fund.

The social performance measures proposed rely on information provided by independent agencies as the Social Investment Forum(SIF) which bases their information on data directly provided by mutual funds' managers without checking transparency and accuracy of this information which in most of the cases is too imprecise. For this reason we propose two different scenarios: LSRD and HSRD which means a negative or positive measure from the information provided for the agency.

10.3.1 Empirical Information

Our empirical study consists of a portfolio optimization problem applied to 110 U.S. domiciled large cap equity mutual funds. For each mutual fund, we have 521 observations (weekly returns) in our disposal, during the period between 08/27/2000 to 08/21/2010. The empirical information includes the following data on the opportunity set of funds over the period 2000–2010 under consideration:

(a) Time series of weekly returns
(b) Expected returns
(c) Covariance matrix
(d) Environmental indices of funds

Due to limited space, which does not permit to display large numerical tables in full, the tables are presented in extract.

10.3.2 Applying CP to the Portfolio Selection Process

From Sect. 10.2, the step by step process is as follows. First compute Markowitz's $E - V$ efficient frontier by Eqs. (10.1)–(10.3), namely:

$$\min V_F = XVX^T \tag{10.6}$$

subject to:

$$E_F = \sum_{i=1}^{n} E_i x_i \geq e_0 \tag{10.7}$$

$$\sum_{i=1}^{n} x_i = 1 \tag{10.8}$$

where,

E_F = expected return of fund F whose components E_i $(i = 1, \ldots m)$ are displayed in Table 10.1, third column.
V_F = variance of fund F.
$\mathbf{X} = (x_1, \ldots x_i \ldots x_{110})$
$\mathbf{V}$ = covariance matrix (sized 110×110) given by Table 10.2.
$X^{\mathbf{T}}$ = transposed X vector.
e_0 = parametric target or aspiration level for expected return E_F. We consider the range:

$$0 < e_0 \leq e_{0max} \tag{10.9}$$

Table 10.1 Weekly returns, expected returns and environmental indexes

	Weekly returns								Environmental indexes	
Fund code	1	2	3	...	519	520	521	Expected returns	LSRD	HSRD
1	2.2	−3.45	−0.61		1.31	−3.36	−0.21	−0.0134	0.35	1.16
2	2.19	−3.46	−0.63		1.26	−3.36	−0.23	−0.0311	0.31	1.04
3	2.19	−3.46	−0.63		1.29	−3.37	−0.23	−0.0292	0.29	1.22
24	1.83	0.9	−1.21		2.18	−3.64	−0.55	0.0263	0.36	1.09
25	1.52	−0.84	−1.6		1.16	−3.61	−0.27	0.0619	0.35	1.20
26	0.89	−1.74	−0.57		1.33	−4.31	−0.69	0.0093	0	0
108	0.71	1.73	−0.46		1.89	−3.57	−1.07	−0.0034	0	0
109	2.71	−3.3	−2.61		1.63	−3.62	−1.22	−0.0301	0	0
110	0.89	−1.57	−0.97		1.29	−4.27	−0.66	0.0307	0	0

Table 10.2 Covariance Matrix

	1	2	3	24	25	26	108	109	110
1	9.1052	9.1053	9.0958	7.7725	6.748	7.6067	8.1918	7.5697	7.5573
2	9.1053	9.1061	9.0962	7.7747	6.7496	7.6074	8.1916	7.5707	7.5583
3	9.0958	9.0962	9.0875	7.7665	6.7432	7.5991	8.18	7.5594	7.5506
24	7.7725	7.7747	7.7665	8.5039	6.5067	7.3737	7.3508	6.989	7.3381
25	6.748	6.7496	6.7432	6.5067	5.9602	6.3841	6.3722	6.1431	6.401
26	7.6067	7.6074	7.5991	7.3737	6.3841	7.2742	7.1791	6.8759	7.1317
108	8.1918	8.1916	8.18	7.3508	6.3722	7.1791	8.3365	7.5909	7.2071
109	7.5697	7.5707	7.5594	6.989	6.1431	6.8759	7.5909	7.2695	6.8788
110	7.5573	7.5583	7.5506	7.3381	6.401	7.1317	7.2071	6.8788	7.5115

In Table 10.3, first column, the scale of parameters is displayed from a lower limit 0.018207 to an upper limit 0.108, the lower limit being close to zero. This scale is given by Matlab, which has only considered positive feasible targets. In the second and third columns, the E_F portfolio expected return and the V_F portfolio variance resulting from the Markowitz's model are recorded. In the fourth and fifth columns, values E_F and V_F are normalized by the following equations, respectively:

$$\theta_1 = \frac{E_F - E_{Fmin}}{E_{Fmax} - E_{Fmin}} \tag{10.10}$$

$$\theta_2 = \frac{V_{Fmax} - V}{V_{Fmax} - V_{Fmin}} \tag{10.11}$$

In Eqs. (10.10) and (10.11), the θ_1 profitability index and the θ_2 safety index range between 0 and 1. Notice that $\theta_2 = 0$ corresponds to the largest variance, which means the highest value of risk, while $\theta_2 = 1$ corresponds to the lowest variance, which means the lowest value of risk. The normalized ideal point $\theta_1^* = 1$ and $\theta_2^* = 1$.

In Table 10.4, the portfolio weights as obtained by Markowitz's $E - V$ model (10.6)–(10.8) are recorded for each e_0 target.

In Table 10.1, two potential scenarios are considered. First, Low Social Responsibility Degree (LSRD). Second, High Social Responsibility Degree (HSRD).

10.3.2.1 First Scenario LSRD

From Table 10.3, the step by step process to bound the investor's optimum portfolio is as follows.

Table 10.3 Markowitz's E-V efficient frontier: Normalized profitability and safety indices

e_0	E_F	V_F	θ_1	θ_2
0.018988	0.018988	0.081708	0	1
0.021303	0.021303	0.081863	0.026014	0.99998
0.0244	0.0244	0.082551	0.060802	0.99991
0.027496	0.027496	0.083793	0.095587	0.99978
0.030592	0.030592	0.085587	0.13037	0.99958
0.033689	0.033689	0.087933	0.16516	0.99933
0.036785	0.036785	0.09084	0.19994	0.99902
0.039881	0.039881	0.094343	0.23472	0.99865
0.042977	0.042978	0.09848	0.26951	0.9982
0.046074	0.046074	0.10331	0.3043	0.99769
0.04917	0.04917	0.10884	0.33908	0.99709
0.052266	0.052266	0.11515	0.37387	0.99642
0.055363	0.055363	0.1223	0.40865	0.99565
0.058459	0.058459	0.1304	0.44344	0.99478
0.061555	0.061555	0.13961	0.47822	0.9938
0.064652	0.064652	0.15012	0.51301	0.99267
0.067748	0.067748	0.16207	0.5478	0.99139
0.070844	0.070844	0.17568	0.58258	0.98993
0.073941	0.07394	0.19131	0.61736	0.98826
0.077037	0.077037	0.20986	0.65215	0.98627
0.080133	0.080133	0.23325	0.68693	0.98377
0.08323	0.08323	0.2635	0.72172	0.98053
0.086326	0.086326	0.30384	0.7565	0.9762
0.089422	0.089422	0.36148	0.79129	0.97003
0.092518	0.092518	0.45083	0.82607	0.96046
0.095615	0.095615	0.60109	0.86086	0.94436
0.098711	0.098711	0.87124	0.89565	0.91542
0.10181	0.10181	1.4078	0.93043	0.85794
0.1049	0.1049	2.4649	0.96521	0.74471
0.108	0.108	9.4166	1	0

Step 1. Establish the environmental constraint (10.4) for $k = 1$. From Table 10.1, and considering an environmental target $e_0 = 0.0065$, this constraint is stated as follows:

$$0.4\, x_1 + 0.3\, x_2 + \ldots + 0.0\, x_{110} \geq 0.0065 \qquad (10.12)$$

Step 2. Check whether or not constraint (10.12) is satisfied by each e_0 value. In Table 10.4 bottom the 14 portfolios, which do not satisfy that constraint are displayed.

Table 10.4 Markowitz's E-V efficient frontier: Portfolio weights

Portfolio weights	Numerical values of portfolio targets e_0			
	0.018207	0.021303	0.061555	0.108
X_1	0.011695	0.011483	0.007331	0
X_2	0.012209	0.011337	0	0
…	…	…	…	…
X_{110}	0.015878	0.015224	0.000357	0
	Is the environmental constraint satisfied by the portfolio?			
$K = 1$	*Yes*	*Yes*	*No*	*Yes*
$K = 2$	*Yes*	*Yes*	*Yes*	*Yes*

Table 10.5 Bounds on the standard investor's utility optimum on the efficient frontier: LSRD scenario

(1)	(2)	(3)	(4)	(5)
0.01820	0.0000	1.0000	1.0000	0.0000
0.02130	0.0260	1.0000	1.0260	0.0260
0.02440	0.0608	0.9999	1.0607	0.0608
0.02749	0.0956	0.9998	1.0954	0.0956
0.03059	0.1304	0.9996	1.1299	0.1304
0.03368	0.1652	0.9993	1.1645	0.1653
0.03678	0.1999	0.9990	1.1990	0.2001
0.03988	0.2347	0.9986	1.2334	0.2350
0.04297	0.2695	0.9982	1.2677	0.2700
0.04607	0.3043	0.9977	1.3020	0.3050
0.04917	0.3391	0.9971	1.3362	0.3401
0.095615	0.8609	0.9444	1.8052	0.9116
0.098711	0.8956	0.9154	**1.8111**	**0.9784**
0.10181	0.9305	0.8579	1.7884	1.0845
0.1049	0.9652	0.7447	1.7099	1.2961
0.108	1.0000	0.0000	1.0000	–

(1) LSRD efficient portfolios: e_0 targets; (2)–(3) Normalized mean value and safety $(\theta_1 - \theta_2)$; (4) $(\theta_1 + \theta_2)$ value; (5) (θ_1/θ_2) ratio

Step 3. Remove the e_0 targets corresponding to the 14 portfolios just mentioned in Step 2. Therefore, only 16 portfolios are kept, which are denoted by LSRD portfolios.

Step 4. Determine the bounds of the investor's utility optimum on the efficient frontier. As explained in Chap. 9, these bounds are given for each investor's profile $r_0(w_1/w_2)$ by the CP frontier points $L_1(r_0)$ and $L_\infty(r_0)$. For this task, construct Table 10.5, where the particular profile $r_0 = 1$ of standard investors is considered.

In Table 10.5, column (4), the largest value is 1.8111. This corresponds to the L_1 bound, which is the frontier point targeted $e_0 = 0.098711$. See column (1). In this table, column (5), the θ_1/θ_2 ratio closest to 1 is 0.9784, which corresponds to the L_∞ bound targeted $e_0 = 0.098711$. As the L_1 and L_∞ coincide (see Sect. 9.4), the investors utility optimum is the $L_1 = L_\infty$ portfolio just determined.

10.3.2.2 Second Scenario HSRD

From Table 10.3, the step by step process to bound the investor's optimum portfolio is as follows.

Step 1. Establish the environmental constraint (10.5) for $k = 2$. From Table 10.1, and considering an environmental target $e_0 = 0.22$, this constraint is stated as follows:

$$1.2\,x_1 + 1.0\,x_2 + \ldots + 0.0\,x_{110} \geq 0.22 \tag{10.13}$$

Step 2. Check whether or not constraint (10.13) is satisfied by each e_0 value. In Table 10.4 bottom the 12 portfolios, which do not satisfy that constraint are displayed.
Step 3. Remove the e_0 targets corresponding to the 12 portfolios just mentioned in Step 2. Therefore, only 18 portfolios are kept, which are denoted by HSRD portfolios.
Step 4. Determine the bounds of the investor's utility optimum on the efficient frontier. As explained in Chap. 9, these bounds are given for each investor's profile $r_0(w_1/w_2)$ by the CP frontier points $L_1(r_0)$ and $L_\infty(r_0)$. For this task, construct Table 10.6, where the particular profile $r_0 = 1$ of standard investors is considered.
As readers can check, the results obtained from Table 10.6 are the same results just obtained from Table 10.5 for the LSRD scenario. In Table 10.6, column (4), the largest value is 1.8111. This corresponds to the L_1 bound, which is the frontier point targeted $e_0 = 0.098711$. See column (1). In this table, column (5), the θ_1/θ_2 ratio closest to 1 is 0.9784, which corresponds to the L_∞ bound targeted $e_0 = 0.098711$. As the L_1 and L_∞ coincide (see Sect. 9.4), the investors utility optimum is the $L_1 = L_\infty$ portfolio just determined.

Table 10.6 Bounds on the standard investor's utility optimum on the efficient frontier: HSRD scenario

(1)	(2)	(3)	(4)	(5)
0.0190	0.0000	1.0000	1.0000	0.0000
0.0213	0.0260	1.0000	1.0260	0.0260
0.0244	0.0608	0.9999	1.0607	0.0608
0.0275	0.0956	0.9998	1.0954	0.0956
0.0306	0.1304	0.9996	1.1299	0.1304
0.0337	0.1652	0.9993	1.1645	0.1653
0.0368	0.1999	0.9990	1.1990	0.2001
0.0399	0.2347	0.9986	1.2334	0.2350
0.0430	0.2695	0.9982	1.2677	0.2700
0.0461	0.3043	0.9977	1.3020	0.3050
0.0492	0.3391	0.9971	1.3362	0.3401
0.0523	0.3739	0.9964	1.3703	0.3752
0.0554	0.4087	0.9957	1.4043	0.4104
0.0956	0.8609	0.9444	1.8052	0.9116
0.0987	0.8956	0.9154	**1.8111**	**0.9784**
0.1018	0.9305	0.8579	1.7884	–
0.1049	0.9652	0.7447	1.7099	–
0.1080	1.0000	0.0000	1.0000	–

(1) HSRD efficient portfolios: e_0 targets; (2)–(3) Normalized mean value and safety ($\theta_1 - \theta_2$); (4) ($\theta_1 + \theta_2$) value; (5) (θ_1/θ_2) ratio

Conclusions

We propose a MCDM approach to select efficient portfolios of funds, where the ethical component is articulated by introducing an SRI constraint. An alternative method could include the SRI dimensions as a new objective together with the classical financial return-risk targets. In this case, a problem arises: how to elicite preferences weights for financial and non financial criteria. Surveys to elicit the community-wide preferences as a whole would be cumbersome, costly and eventually useless. In fact, Arrow's impossibility theorem states that constructing social preferences from individual preferences is rather impossible. More precisely, no rank order voting system can convert the ranked preferences of individuals (investors in our SRI context) into a community-wide complete and transitive ranking when the number of alternatives is 3 or more.

We propose a Compromise Programming model as a method suitable for those problems presenting conflicting objectives. This method provides investors with several compromise solutions among which decide, ranging from maximum efficiency to maximum equilibrium between the attachment's

(continued)

levels of financial return and financial risk. SRI dimension is included in the CP model as a constraint.

To place a SRI constraint (characterized by saying that the SRI level in the fund should be greater than a given target) has certain disadvantages. First, the constraint is not a flexible but rigid piece in the model. Second, the target is fixed by the fund manager but not by the fund investors. This last drawback might be mitigated if the targets chosen for different funds were published. Thanks to this transparency, each potential investor could rank the set of funds from his/her SRI preferences.

A real case study is applied to 110 U.S. domiciled large cap equity mutual funds. Empirical information on weekly returns over 10 years, and two SRD measures for each fund are displayed. From this data, expected returns, covariance matrices and Markowit'z E-V efficient frontiers are obtained. Finally the CP model with the SRI constraint give us the L_1 and L_∞ bounds. In this work, several maximum efficiency solutions are obtained under two different scenarios: low and high social responsibility degree and considering several minimum bounds on the SRD of the portfolio. Results are displayed in several tables.

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Chapter 11
Evaluating Fund Performance from Financial and SRI Criteria

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Abstract Classical approaches to financial performance of funds have the following characteristics. First, the performance composite measure is only capable of combining two criteria, which are usually profitability and risk. In purely financial analyses, this limitation is justified because profitability and risk are the more interesting criteria for most investors in funds. However, in ethical financial analysis this limitation prevents the possibility of combining multiple SRI and financial criteria. Second, the classical approaches are designed regardless of the investor's preferences for each criterion. An advantage is that the performance ranking of funds can be used whatever the investor. A disadvantage is that many investors want to manage performance rankings constructed from their preferences for ethical and financial criteria. To overcome these difficulties, the performance ranking can be constructed by a CP-based model extended to multiple SRI and financial criteria with the possibility of introducing preference weights. In this chapter, a CP model with linear-quadratic achievement function is presented and applied to an actual financial case as well as to a combined SRI-financial case.

11.1 Performance Composite Measures in Classic Financial Analysis

To discern between reliable and unreliable opportunities of investing, performance analysis is an important piece of knowledge. Data for this performance are obtained from stock market information and other available sources. Critical variables to

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measure fund performance are historical returns and variance of returns, the latter being an estimate of the fund volatility risk. Other financial variables such as liquidity are sometimes added to the analysis. However, liquidity is not a significant concern in the case of funds, because shares in funds can be sold to the fund itself at anytime without paying penalties. In the SRI case, financial performance should be combined with ethical performance.

Modalities of performance to be hereafter considered are as follows:

(a) Purely financial analysis regardless of the investor's preferences. This is the usual modality in financial literature. Procedures to address this performance are first the Sharpe ratio, which involves a performance composite measure, and second the Graham-Harvey metric, which does not. The investor's preferences for profitability and risk are not considered in these procedures. Thus, financial performance provides neutral and objective results, which are not colored by specific judgments and values of a particular investor.
(b) Purely financial analysis with investor's preferences. Financial consultants use this modality to advise their clients. This performance is tailored to the values and targets of each client, so that its results can not be extended to other investors.
(c) Ethical-Financial performance, which combines the financial historical behavior of each fund with its ethical historical behavior. In this analysis, the investor's preferences for SRI play their role versus the investor's financial preferences.

11.2 Purely Financial Performance Analysis Regardless of the Investor's Preferences

Until the seminal paper by Treynor (1965), no portfolio performance composite measure was employed in the literature, so that the analysis of performance was tackled by comparing rates of return on portfolios included in the same class of risk. At that time, either the portfolio variance or another dispersion measure was already used to establish the risk classes. Besides the Treynor ratio, the standard approaches to fund performance were due to Sharpe (1966) and Jensen (1968).

Since the late 1960s, when Treynor's and Sharpe's composite performance measures were disseminated in the light of capital asset pricing models (CAPM), most approaches to performance have been made in terms of reward to variability, so that both expected return and risk measures are summarized with one, either the Treynor (1965) ratio or the Sharpe (1966) ratio. The classic Sharpe ratio, is defined as follows:

$$S_i = (E_i - E_f)/\sigma_i \tag{11.1}$$

where, E_i and σ_i are the expected return and the standard deviation of the ith fund, while E_f is the risk free rate. To define a precise level of E_f is somewhat hazardous as risk free investments do not exist in the real world. A proxy for E_f is Treasury bill rates, whose levels change over time from a country to another. Due to this variability, the proxy is often constructed as a mix of treasury bills.

In 1994, Sharpe devised another version of his ratio, the so called information ratio, which is more cumbersome but has advantages in some circumstances.

Other performance approaches are as follows.

(1) Modigliani and Modigliani (1997) ratio, which leads to the same ranking as the Sharpe ratio.
(2) Downside risk performance (Nawrocki 1992, 1999), which is a great departure from the standard approaches to risk measurement, and therefore, appears controversial.
(3) Graham and Harvey (1997) performance approaches, which go back to the way of analysing performance without using a composite measure. There are two versions of this method: Graham-Harvey "Measure 1" ($GH1$) and Graham-Harvey "Measure 2" ($GH2$). These versions can be summarized as follows.
    (a) $GH1$. This measure is implemented by levering or unlevering the S&P 500 future portfolio to get the same volatility as the fund to be evaluated over a given period. In $GH1$, the difference between the fund return and the return on the volatility-matched S&P 500 future portfolio is computed.
    (b) $GH2$. This measure is implemented by levering up or down the fund investment. For this purpose, a mix of treasury bills and the fund returns is used. In this way, the fund to be evaluated should reach equal volatility as the S&P 500. We have:

$$GH2 = R^* - R_{SP_{500}}$$

    where R^* is the fund return adjusted to the $S\&P500$ volatility level.

11.3 Purely Financial Performance and Combined SRI-Financial Performance from the Investor's Preferences

Suppose that a financial consultant should advice a given client about investing in mutual funds. Then, the advice should obviously consider the client's preferences for financial criteria such as profitability and risk. If the investor is also interested in SRI, his/her ethical preferences should be also considered.

11.3.1 Purely Financial Performance

The preference-based performance analysis to be undertaken by the consultant is developed as follows.

(i) **Basic information and criteria**. There are m mutual funds denoted by F_i ($i = 1, 2, \ldots, m$). As to the reference period, we use daily prices and weekly returns on each fund, which are observed over a 4-year historical period, which is the same for all funds. We consider two criteria, profitability and risk. The risk criterion is converted into the safety criterion, which behaves as "the more the better". As usual, profitability is measured by the expected return or mean value, while risk is measured by the variance of returns. As an extended measure of risk, downside risk could be alternatively used.

(ii) **Compromise programming (CP) model**. To establish the complete ranking of funds, the step by step process is as follows.

First step. Compute weekly returns on each fund over the reference period. For this purpose we use the standard equation:

$$\text{Return} = \frac{(\text{ending price} - \text{beginning price} + \text{cash flow})}{\text{beginning price}}$$

Second step. From the historical series of weekly returns, compute the expected return and variance for each fund.

Third step. Compute the profitability index and the safety index for each fund, by normalizing expected return and variance, respectively, as follows

$$\theta_{1i} = \frac{E_i - E_{min}}{E_{max} - E_{min}} \tag{11.2}$$

$$\theta_{2i} = \frac{v_i - v_{min}}{v_{max} - v_{min}} \tag{11.3}$$

where,

θ_{1i} and θ_{2i} are profitability index and safety index, respectively, for the ith fund.
E_i and v_i are expected return and variance, respectively, for the ith fund.
E_{max} and E_{min} are max E_i and min E_i in the set of funds.
v_{max} and v_{min} are max v_i and min v_i in the set of funds.

Notice that:

(a) From Eqs. (11.2) and (11.3), we have $0 \le \theta_{1i} \le 1$ and $0 \le \theta_{2i} \le 1$ for all i.
(b) Equation (11.3) has converted risk measure v_i into a safety normalized measure θ_{2i}, which is a "the more the better" variable.

Fourth step. Determine the ideal point. From the third step, the CP anchor values are $\theta_1^* = \theta_2^* = 1$, namely, we have the infeasible ideal point $I(1, 1)$.

Fifth step. Elicit the preference weights. For the profitability criterion and the safety criterion, the preference weights are denoted w_1 and w_2, respectively. These weights can be elicited by an interactive dialogue between the analyst and the investor, the results depending on the aggressive, standard or conservative profile of each investor. As we have two criteria only, the analyst only needs a single pairwise comparison to elicit these weights through a simple question easy to answer.

Sixth step. Specify the CP metric. Some of the following metrics are appealing to the analyst.

(a) **Metric 1**, which leads to the following D_{Li} linear distances:

$$D_{Li} = w_1(1-\theta_{1i}) + w_2(1-\theta_{2i}); \qquad i = 1, 2, \ldots, m \tag{11.4}$$

An advantage of this metric is simplicity, while a disadvantage is corner (extreme) solutions.

(b) **Infinity norm**, which leads to the following $D_{\infty i}$ distances:

$$D_{\infty i} = \lim_{h\to\infty} \left[{w_1}^h (1-\theta_{1i})^h + {w_2}^h (1-\theta_{2i})^h \right]^{1/h} \qquad i = 1, 2, \ldots, m \tag{11.5}$$

This metric is familiar to many analysts; however, it requires assuming extreme risk aversion, which is often an unrealistic assumption.

(c) **Linear-quadratic composite metric**. This has been defined in subsection 8.4.1 and stated by Eq. (8.21), in which symbols V_1, V_2, y_1 and y_2 are now symbols w_1, w_2, θ_1 and θ_2, respectively. With this notation, we have the following linear-quadratic D_{LQi} distances:

$$D_{LQi} = \frac{1-\theta_{1i}}{1-w_1} + \frac{1-\theta_{2i}}{1-w_2} + \frac{1}{2}\left[(1-\theta_{1i})^2 + (1-\theta_{2i})^2 \right]; \quad i = 1, 2, \ldots, m \tag{11.6}$$

As noted in Chap. 8, this metric relies on a utility-based assumption reflecting a trade-off between achievement and balance, which provide non-corner solutions.

From the above pros and cons of the different metrics, we select the linear-quadratic composite metric leading to Eq. (11.6).

Seventh step. From Eq. (11.6) compute each s_i score for fund F_i by the following equation:

$$s_i = D_{LQ_{max}} - D_{LQi}; \quad i = 1, 2, \ldots, m \tag{11.7}$$

where D_{LQmax} denotes max D_{LQi} for all i. Equation (11.7) is characterized by saying that distances D_{LQi}, which are the more the worse indices, should be converted into the more the better scores. These scores give us the complete ranking of fund performance.

11.3.2 Combined SRI-Financial Performance

This analysis is analogous to Sect. 11.3.1 with the following distinctions.

(i) **Criteria**. Here, we consider: (a) A financial criterion given by (11.1), namely, the classical Sharpe ratio; and (b) An ethical criterion, which is measured by an SRI indicator (for example, the proposed in Chap. 4). By normalizing these "the more the better" criteria as usual, we have:

$$\theta_{1i} = \frac{S_i - S_{min}}{S_{max} - S_{min}} \tag{11.8}$$

$$\theta_{2i} = \frac{H_i - H_{min}}{H_{max} - H_{min}} \tag{11.9}$$

$$0 \leq \theta_{1i},\ \theta_{2i} \leq 1$$

where,
$S_i =$ Sharpe ratio of the ith fund.
$S_{min} =$ Minimum level of the Sharpe ratio in the set of funds.
$S_{max} =$ Maximum level of the Sharpe ratio in the set of funds.
$H_i =$ Synthetic indicator for the ith fund.
$H_{min} =$ Minimum level of the SRI indicator in the set of funds.
$H_{max} =$ Maximum level of the SRI indicator in the set of funds.

Frequently, the values of the SRI indicator are already normalized, so that normalization is not required.

(ii) **Preference weights**. In our context, weights w_1 and w_2 refer to the investor's preferences for the financial criterion and the ethical criterion, respectively. They are elicited by an interactive dialogue between the analyst and the investor.

Finally, each s_i performance score is computed by Eqs. (11.8)–(11.9).

11.4 Numerical Examples

To illustrate the performance approach in Sect. 11.3, some numerical examples are developed hereafter, one of them concerning purely financial performance while the other regarding combined SRI-financial performance.

11.4.1 An Actual Case of Purely Financial Performance

This real world case deals with CaixaBank, which is a well-known bank group in Spain. It is a merger of two traditional savings banks, founded in 1904 and 1844 in Catalonia. In year 2008 (in which the observation period ends), this group had around 26,000 employees and 10.5 million customers. Other data about CaixaBank in 2008 are turnover of 396,000 million Euros and deposits of 231,000 million Euros. CaixaBank has around 5,500 offices and around 8,100 automatic teller machines. In 2005 (in which the observation period begins), CaixaBank Group offered 116 mutual funds to their customers, which grew to 125 in 2008. From these funds, 59 funds have been selected because they are the only ones with available data over 3 years or more. They are denoted by F_i $(i = 1, 2, , 59)$.

In year 2011, the situation just described has slightly changed. For example, turnover has increased to 436,000 million Euros while the offices have decreased to 5,247 Euros. These changes do not affect the present research.

(i) **Basic information and criteria**. We analyze 59 mutual funds, which are all CaixaBank funds with complete numerical information on prices and returns over the observation period (May 1st, 2005–May 1st, 2008). The performance criteria are profitability and risk, measured by expected returns E_i and variance v_i, respectively.

(ii) **Applying the CP model**. From Sect. 11.3.1, the step by step process is numerically developed as follows.

First step. Compute weekly returns on funds F_i $(i = 1, 2, \dots 59)$ over period May 1st, 2005–May 1st, 2008 by using the standard return equation (see First step, Sect. 11.3.1).

Second step. For each fund F_i $(i = 1, 2, \dots 59)$ compute expected return E_i and variance v_i from the historical series of 156 weekly returns. In Table 11.1, second and third columns, these parameters are numerically displayed. Due to space limitations, only a fragment of the table is presented.

Third step. Compute normalized indexes θ_{1i} and θ_{2i} of profitability and safety $(i = 1, 2, \dots, 59)$ by using Eqs. (11.2) and (11.3), respectively, with the numerical data obtained in the Second step. In Table 11.1, fourth and fifth columns, these normalized indices are shown. As the number of funds is very high, Table 11.1 only displays some of them.

Fourth step. Determine the ideal point. As stated in Sect. 11.3.2, fourth step, the CP infeasible ideal point is $\theta_{1i} = 1$ and $\theta_{2i} = 1$.

Fifth step. Specify the preference weights. From opinions given by some of CaixaBank fund managers, an approximation to the most usual preference weights w_1 and w_2 for the profitability criterion and the safety criterion is as follows:

$w_1 = 0.75$ and $w_2 = 0.25$ for aggressive investors
$w_1 = 0.50$ and $w_2 = 0.50$ for standard investors
$w_1 = 0.25$ and $w_2 = 0.75$ for conservative investors

Table 11.1 Fund performance for CaixaBank: Normalized indices of profitability and safety. Period: 2005–2008 (fragment)

Fund code	Profitability index θ_{1i}	Safety index θ_{2i}	CP linear-quadratic distance D_{LQi}	Score s_i
F29	0.595	0.858	1.199	4.712
F30	0.592	0.859	1.2	4.711
F35	0.446	0.902	1.29	4.621
F34	0.446	0.902	1.29	4.621
F25	0.262	0.98	1.338	4.572
F31	0.456	0.884	1.343	4.568
F2	0.28	0.969	1.344	4.567
F26	0.249	0.984	1.348	4.562
F28	0.238	0.985	1.367	4.544
F4	0.236	0.977	1.401	4.509
...	...	...	...	...

Table 11.2 Fund performance for CaixaBank and aggressive investors: ranking scores (fragment)

Fund code	Profitability index θ_{1i}	Safety index θ_{2i}	CP linear-quadratic distance D_{LQi}	Score s_i
F48	1	0.559	0.685	4.722
F51	0.968	0.522	0.881	4.526
F38	0.899	0.555	1.103	4.304
F49	0.732	0.636	1.66	3.747
F41	0.721	0.619	1.737	3.67
F44	0.75	0.529	1.769	3.638
F39	0.714	0.599	1.8	3.607
F29	0.595	0.858	1.899	3.507
F30	0.592	0.859	1.914	3.493
F43	0.697	0.557	1.948	3.459
...	...	...	...	...

A different ranking of funds will be obtained for each investor profile, by using the above weights.
Sixth step. Compute distances D_{LQi} by Eq. (11.6), for each investor's profile, which yields:

$$D_{LQi} = \frac{1-\theta_{1i}}{1-w_1} + \frac{1-\theta_{2i}}{1-w_2} + \frac{1}{2}\left[(1-\theta_{1i})^2 + (1-\theta_{2i})^2\right]; \quad i = 1, 2, \ldots, m \tag{11.10}$$

Seventh step. Compute the s_i score for each F_i fund by Eq. (11.7). In Tables 11.2–11.4, these scores are displayed for aggressive, standard and conservative investors, respectively. Due to the high number of funds

Table 11.3 Fund performance for CaixaBank and standard investors: ranking scores (fragment)

Fund code	Profitability index θ_{1i}	Safety index θ_{2i}	CP linear-quadratic distance D_{LQi}	Score s_i
F48	1	0.559	0.978	3.473
F51	0.968	0.522	1.134	3.317
F29	0.595	0.858	1.185	3.266
F30	0.592	0.859	1.191	3.26
F38	0.899	0.555	1.197	3.254
F49	0.732	0.636	1.366	3.085
F41	0.721	0.619	1.433	3.018
F35	0.446	0.902	1.463	2.988
F34	0.446	0.902	1.463	2.988
F31	0.456	0.884	1.474	2.977
...	...	...	...	...

Table 11.4 Fund performance for Caixa Bank and conservative investors: ranking scores (fragment)

Fund code	Profitability index θ_{1i}	Safety index θ_{2i}	CP linear-quadratic distance D_{LQi}	Score s_i
F29	0.595	0.858	1.199	4.712
F30	0.592	0.859	1.2	4.711
F35	0.446	0.902	1.29	4.621
F34	0.446	0.902	1.29	4.621
F25	0.262	0.98	1.338	4.572
F31	0.456	0.884	1.343	4.568
F2	0.28	0.969	1.344	4.567
F26	0.249	0.984	1.348	4.562
F28	0.238	0.985	1.367	4.544
F4	0.236	0.977	1.401	4.509
...	...	...	...	...

handled, only a fragment of each table is presented to show the top 10 funds in each ranking.

The results are very consistent. At the top of the aggressive ranking Table 11.2 fund number 48 reaches maximum profitability and average safety. At the top of the conservative ranking, fund number 29 has high safety and average profitability. As to the aggressive ranking, fund number 51 ranks second, with almost maximum profitability and average safety. As to the conservative ranking, fund number 30 ranks second, with high safety and average profitability. This consistency also holds through the successive positions. Concerning standard investors, the top and the second-ranked funds are the same as the top and the second-ranked funds in the aggressive ranking, while the third and the fourth-ranked funds are the same as the top and the second-ranked funds in the conservative ranking. This consistent behavior is maintained.

11.4.2 An Example of Combined SRI-Financial Performance

Consider a set of funds F_i ($i = 1, 2, \ldots, 12$) whose financial performances are estimated by the S_i Sharpe ratio (11.1) and whose ethical performances are given by the H_i environmental synthetic indicator (see Sect. 11.3.2). In Table 11.5, these data are displayed.

Our problem is to compute a performance index which combines financial and ethical performances. The process is as follows.

First step. Normalize the S_i and H_i variables by Eqs. (11.2)–(11.3), namely:

$$\theta_{1i} = \frac{S_i - 0.040}{0.367 - 0.040} = 3.056(S_i - 0.040)$$

$$\theta_{2i} = \frac{H_i - 0.340}{0.980 - 0.340} = 1.562(H_i - 0.040); \quad i = 1, 2, \ldots, 12$$

Second step. Specify preference weights w_1 and w_2 for the financial and the environmental criteria, respectively. According to the investor's profile, these weights are established as follows:

$w_1 = 0.25$ and $w_2 = 0.75$ for investors deeply concerned about the environment
$w_1 = 0.50$ and $w_2 = 0.50$ for investors moderately concerned about the environment
$w_1 = 0.75$ and $w_2 = 0.25$ for investors slightly concerned about the environment

Table 11.5 Sharpe ratios and environmental synthetic indicators for 12 funds

Fund code	S_i	H_i
F1	0.048	0.82
F2	0.127	0.98
F3	0.042	0.94
F4	0.070	0.68
F5	0.040	0.75
F6	0.136	0.54
F7	0.119	0.66
F8	0.072	0.72
F9	0.077	0.83
F10	0.367	0.78
F11	0.128	0.34
F12	0.071	0.81

Third step. Compute distances D_{LQi} by Eq. (11.6) for each investor's profile. Investors deeply concerned about the environment:

$$D_{LQi} = \frac{1-\theta_{1i}}{1-0.25} + \frac{1-\theta_{2i}}{1-0.75} + \frac{1}{2}\left[(1-\theta_{1i})^2 + (1-\theta_{2i})^2\right] \tag{11.11}$$

Investors moderately concerned about the environment:

$$D_{LQi} = \frac{1-\theta_{1i}}{1-0.50} + \frac{1-\theta_{2i}}{1-0.50} + \frac{1}{2}\left[(1-\theta_{1i})^2 + (1-\theta_{2i})^2\right] \tag{11.12}$$

Investors slightly concerned about the environment:

$$D_{LQi} = \frac{1-\theta_{1i}}{1-0.75} + \frac{1-\theta_{2i}}{1-0.25} + \frac{1}{2}\left[(1-\theta_{1i})^2 + (1-\theta_{2i})^2\right]; \quad i = 1, 2, \ldots, 12 \tag{11.13}$$

Fourth step. Compute each s_i score by Eq. (11.7). As $D_{LQimax} = 5.74$, 3.66, and 15.79, for $w_1 = 0.25, 0.50$ and 0.75, respectively, the results are as follows. Investors deeply concerned about the environment:

$$s_i = 5.74 - D_{LQI} \tag{11.14}$$

Investors moderately concerned about the environment:

$$s_i = 3.66 - D_{LQI} \tag{11.15}$$

Investors slightly concerned about the environment:

$$s_i = 15.79 - D_{LQI} \tag{11.16}$$

In Tables 11.6–11.8, these scores are recorded for each type of investor, deeply, moderately and slightly concerned about the environment, respectively.

Concerning investors deeply concerned about the environment (see Table 11.6) the top and second ranked funds are funds 2 and 10 respectively. These funds are characterized by medium and low financial performance and high SRI performance indexes. As to investors moderately concerned about the environment (see Table 11.7), the top and second ranked funds are funds 7 and 10 with medium level of performance in both financial and SRI indices. Finally, for investors slightly concerned about the environment, the top and second ranked funds are funds 10 and 2 with the highest financial performance and medium values of SRI performance. Indeed, fund 10 moves from the second position when the investor is deeply or moderately concerned about the environment to the first position when the financial performance is preferred (see Table 11.8).

Table 11.6 Combined SRI-financial performance for investors deeply concerned about the environment

Fund code	Profitability index θ_{1i}	Safety index θ_{2i}	CP linear-quadratic distance D_{LQi}	Score s_i
F2	0.27	1.00	1.24	4.49
F10	1.00	0.69	1.30	4.44
F3	0.01	0.94	2.07	3.67
F9	0.11	0.77	2.54	3.20
F12	0.10	0.73	2.71	3.02
F1	0.03	0.75	2.80	2.94
F8	0.10	0.59	3.32	2.42
F5	0.00	0.64	3.34	2.40
F7	0.24	0.50	3.42	2.32
F4	0.09	0.53	3.61	2.13
F6	0.29	0.31	4.18	1.56
F11	0.27	0.00	5.74	0.00

Table 11.7 Combined SRI-financial performance for investors moderately concerned about the environment

Fund code	Profitability index θ_{1i}	Safety index θ_{2i}	CP linear-quadratic distance D_{LQi}	Score s_i
F7	0.24	0.50	0.67	3.55
F10	1.00	0.69	1.73	2.49
F11	0.27	0.00	2.61	1.62
F6	0.29	0.31	2.66	1.56
F9	0.11	0.77	2.79	1.44
F4	0.09	0.53	2.93	1.30
F1	0.03	0.75	2.95	1.27
F5	0.00	0.64	3.11	1.12
F3	0.01	0.94	3.27	0.95
F12	0.10	0.73	3.28	0.95
F2	0.27	1.00	3.28	0.94
F8	0.10	0.59	4.22	0.00

Table 11.8 Combined SRI-financial performance for investors slightly concerned about the environment

Fund code	Profitability index θ_{1i}	Safety index θ_{2i}	CP linear-quadratic distance D_{LQi}	Score s_i
F10	1.00	0.69	0.47	4.58
F2	0.27	1.00	3.20	1.85
F7	0.24	0.50	4.11	0.94
F6	0.29	0.31	4.23	0.82
F9	0.11	0.77	4.28	0.77
F12	0.10	0.73	4.42	0.62
F3	0.01	0.94	4.55	0.49
F8	0.10	0.59	4.64	0.40
F1	0.03	0.75	4.73	0.31
F4	0.09	0.53	4.78	0.26
F11	0.27	0.00	5.02	0.03
F5	0.00	0.64	5.04	0.00

Conclusions

The suitable choice of a benchmark portfolio is a critical problem when the decision maker takes into account financial criteria together with SRI criteria. We use the classical Sharpe ratio to obtain the purely financial performance regardless of the investor's preferences. To undertake further performance analysis considering the investor's preferences for profitability and risk we propose a CP method to establish a complete ranking of funds. In this case the linear-quadratic composite metric is proposed to obtain the D_{LQi} performance indices that should be converted into the more the better scores to give us the complete ranking of fund performance. A combined SRI-financial performance index is also developed to include the investor's ethical preferences. In this case, the classical Sharpe ratio is considered for the financial performance and the SRI synthetic indicator for the ethical performance. Preferences for the financial criterion or the ethical criterion are elicited through an interactive dialogue between the analyst and the investor. Finally, two illustrative examples are developed to obtain the previously proposed performance indices. The computational process and numerical results are presented through tables.

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Part IV
Other Decision-Making Support Methods

Chapter 12
Ranking Socially Responsible Mutual Funds Based on the Particular Preferences of the Decision Maker

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Abstract Several methods for ranking mutual funds based on financial performance have been developed, but few of them propose a ranking methodology based on their non-financial performance. The aim of this chapter is to present two ranking methods for mutual funds based on their socially responsible performance. The ranking approaches suggested can be understood as complement financial information which can help socially responsible mutual fund managers, individual and institutional investors in their portfolio selection process. Both methods use multiple criteria decision analysis (MCDA) techniques, namely, one is based on AHP (Analytic Hierarchy Process) and the other one apply MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique). The results reveal that an integrated framework using multiple criteria decision analysis (MCDA) techniques could help the investor in selecting a suitable socially responsible mutual funds portfolio, because the consideration of several criteria reflect more precisely the multiple dimensions of this decision making problem.

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12.1 Introduction

Given that most of the academic research is focused on the financial performance of social responsible funds, there exists a necessity for the development of a suitable indicator for the measurement of their social responsible performance which can assess investors on the evaluation of mutual funds. But this indicator must consider the multiple dimensions of social responsibility, regarding both the behaviour of the companies included in the portfolios of the mutual funds and the social performance of the funds themselves. This is the main motivation of this chapter. We will present two methods for ranking mutual funds according to their socially responsible performance and which take into account the different dimensions of their social responsibility. In practice, these methods provide investors with additional information to the financial data in order to allow them to analyse and to rank mutual funds based both on the funds' social responsibility and on the investors' personal preferences.

Initially, in the two ranking methods, an analysis of the criteria relevant for the evaluation of the mutual funds' social responsibility performance is carried out. Once the socially responsible criteria are identified, on the one hand, the first method we will describe proposes a hierarchical model developed within the *Analytic Hierarchy Process (AHP)* (Saaty 1980) framework. This model enables us to consider several social responsibility dimensions in order to rank socially responsible mutual funds. The performance of the AHP-based method proposed is illustrated using five US mutual funds. These funds are ranked based on pairwise comparisons of the levels identified for each criteria and the results are subsequently synthesised using the hierarchy through a computer software. Finally, a comparison of the ranking obtained with the method proposed to some others derived from other social responsibility measurements suggests that using AHP for the analysis of the social responsibility of mutual funds can be of great help for the selection of a suitable socially responsible mutual fund portfolio.

On the other hand, the second method we will analyse uses a multicriteria decision making technique known as *MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique)*, which enables us to quantify the mutual funds' socially responsible attractiveness (Bana e Costa 2005; Bana e Costa and Vansnick 1994). MACBETH is an interactive method for multiple criteria decision analysis based on semantic judgements about the differences in attractiveness of several options to help the decision maker (DM) quantify the relative attractiveness of each option (Bana e Costa and Vansnick 1999). It only requires qualitative preference judgements from the DM. In order to show the working procedure of the method proposed, we also consider a set of US socially responsible equity mutual funds. The results obtained have provided the investors with a ranking of the mutual funds considered according both to their social responsibility and to the particular preferences of the investors.

The two methodologies proposed can be understood as novel ways to mutual funds' socially responsible measurement, which are capable to be adapted to the particular preferences of each investor. This property is highly desired in this kind of indicators, given that socially responsible values change with time, space and personal preferences. Furthermore, these methods provide managers and investors with two illustrative examples of the advantages and strengths of using multicriteria decision making techniques to the mutual funds' portfolio selection problem.[1]

The rest of this chapter is structured as follows. Section 12.2 describes the ranking method proposed which is based on AHP and Sect. 12.3 presents the evaluation of mutual funds' social responsibility performance according to the MACBETH method. Finally, Sect. 12.4 provides some discussion and conclusions.

12.2 Ranking SRI Mutual Funds Based on the Analytical Hierarchy Process (AHP)

12.2.1 Socially Responsible Criteria

As stated in previous chapters, measurement of the social responsibility performance of a mutual fund implies taking into account not only one criterion but several ones, related to the available contents and the transparency of the provided information. In this context, *Multiple Criteria Decision Aiding (MCDA)* techniques can be used as a useful tool for measurement of social responsibility and ranking of mutual funds.

The *Analytic Hierarchy Process (AHP)* is a MCDA technique developed by Saaty (1980). This technique has been subjected to extensive criticism from the methodological, theoretical and technical points of view (see Bana e Costa and Vansnick 2008; Belton and Gear 1983, 1985, among others). In spite of this criticism, Steuer and Na (2003) stated that it is "*extraordinarily elegant in its simplicity, for addressing and analysing discrete alternative problems with multiple conflictive criteria*". Since AHP considers subjective and objective factors in a decision-making process, it allows the active participation of stakeholders, giving managers a rational foundation to make decisions (Saaty 1983).

Several works can be found in the literature related to AHP with finance. Arbel and Orgler (1990) apply the AHP methodology to the evaluation of a bank acquisitions strategy, Meziani and Rezvani (1990) develop a four-level AHP model to select a financing instrument for a foreign investment, and Tarimcilar and Khaksari (1991) present an AHP model for capital budgeting in the health care industry. Besides, AHP has been successfully applied in last years to multiple criteria decision-making problems in the field of business ethics. Harrington (1997) uses AHP to provide a priority or ranking of the social consensus in the context of computing usage surrounding computer virus (computer programs that replicate

[1]This chapter is closely related to and heavily based on Pérez-Gladish and M'Zali (2010) published in the International Journal of Multicriteria Decision Making.

and spread themselves automatically) scenarios. AHP pairwise comparison of social consensus was made on subject-s responses to questions on different types of computer viruses with different consequences.

Millet (1998) established that ethical dilemmas require evaluation of alternatives usually taking into account conflicting criteria. The author showed how AHP can help improvement of ethical decision-making by modelling our values, alternatives, and judgements. Beyond improving the quality of our decisions, the AHP is shown as a useful tool to support the process of examining, justifying, negotiating, and communicating ethical decisions.

Stein and Ahmad (2009) also illustrate how AHP can be applied in the field of ethics. They propose an empirically grounded mathematical model of the magnitude and consequence component of "moral intensity" defined by Jones (1991). The authors illustrate the use of the model in the evaluation of three test cases used in instruments that measure cognitive moral development and then rank-ordered the three cases in terms of magnitude of consequences, broken down into three dimensions: physical, economic and psychological consequences.

For all the above reasons, and taking into account the existence of criticisms to the technique, we have used AHP for the ranking of mutual funds based on several socially responsible criteria, although other MCDA techniques could be also applied to the resolution of this problem.

The AHP methodology can be divided into four major steps:

Step 1. Development of the hierarchy structure:

- Top level: definition of the overall goal of the decision problem.
- Intermediate level: selection of criteria or factors affecting the decision.
- Low level: alternatives.

Step 2. Assign a relative importance of each selection criteria to the goal: once the hierarchy is constructed, the decision-maker begins a prioritisation procedure to determine the relative importance of elements in each level of hierarchy. The elements in each level are compared as pairs with respect to their importance in making the decision under consideration. A verbal scale is used in AHP that enables the decision-maker to incorporate subjectivity, experience and knowledge in an intuitive and natural way. After comparison matrices are created, relative weights are derived from the various elements. The relative weights of the elements of each level with respect to an element in the adjacent upper level are computed as the components of the normalised eigenvector associated with the largest eigenvalue of their comparison matrix.

Step 3. Rank alternatives under each criterion: for this either a direct method or a pairwise comparison-based method can be used. In both cases, it is necessary to develop a comparative database of alternate mutual funds with respect to each criterion.

Step 4. Rank each alternative's contribution to the goal: composite weights are determined by aggregating the weights throughout the hierarchy. This is done by following a path from the top of the hierarchy down to each alternative at the lowest level, and multiplying the weights along each segment of the path. The outcome of this aggregation is a normalised eigenvector of the overall weights of the alternatives. The mathematical basis for determining the weights was established by Saaty (1980). Calculation details can be found in Tables 12.8–12.15.

The first step in AHP is to model the problem as a hierarchy. For this, we explore the aspects of the problem at levels from general to detail, then we express it in the multilevelled way that the AHP requires. A *hierarchy* is a system of ranking and organising ideas where each element of the system, except for the top one, is subordinate to one or more other elements. It allows us to acquire detailed knowledge of a complex reality: we structure the reality into its constituent parts, and these in turn into their own constituent parts, proceeding down the hierarchy as many levels as we care to. At each step, we focus on understanding a single component of the whole, temporarily disregarding the other components at this and all other levels. Similarly, when we approach a complex decision problem, we can use a hierarchy to integrate the large amounts of information into our understanding of the situation. As we build this information structure, we form a better and better picture of the problem as a whole and we increase our global understanding of the complex reality we are studying.

That is the case in the problem we are dealing with. SRI could be broadly defined as a financial management style aimed at optimising financial performance by applying sustainable or socially responsible development principles in the asset allocation process. Two different approaches could be followed for socially responsible mutual funds' investing. The first one applies a financial screening first and subsequently a social responsible screening, while the second one applies first the social responsible screening and then the financial one. In this study, we will not assume that the financial performance is a criterion. We will rank mutual funds on the basis of their social responsibility for a given financial performance.

As described in Chap. 4, defining socially responsible mutual funds' performance is a very complex task. Proper socially responsible measurement requires clear information not only about contents, but also related to the transparency and credibility of the investment process. From the revision of the literature accomplished in Chap. 4 and the current practice of several independent rating agencies, we have tried to identify the fundamental criteria contributing to both dimensions of socially responsible performance of mutual funds (contents and transparency and credibility). Criteria corresponding to each of these dimensions are displayed in Figs. 12.1 and 12.2, which shows the hierarchies for the considered decision-making problem in this work.

Once the hierarchy has been built, AHP is used to establish *priorities* for all its nodes, for what we have requested an anonymous SRI expert to establish the priorities. Priorities are numbers associated with the nodes of the hierarchy which represent the relative weights of the nodes in any group. By definition, the priority of the goal is 1,000. The priorities of the criteria will always add up to 1,000. The same follows with the alternatives. The decision-maker has to make his/her

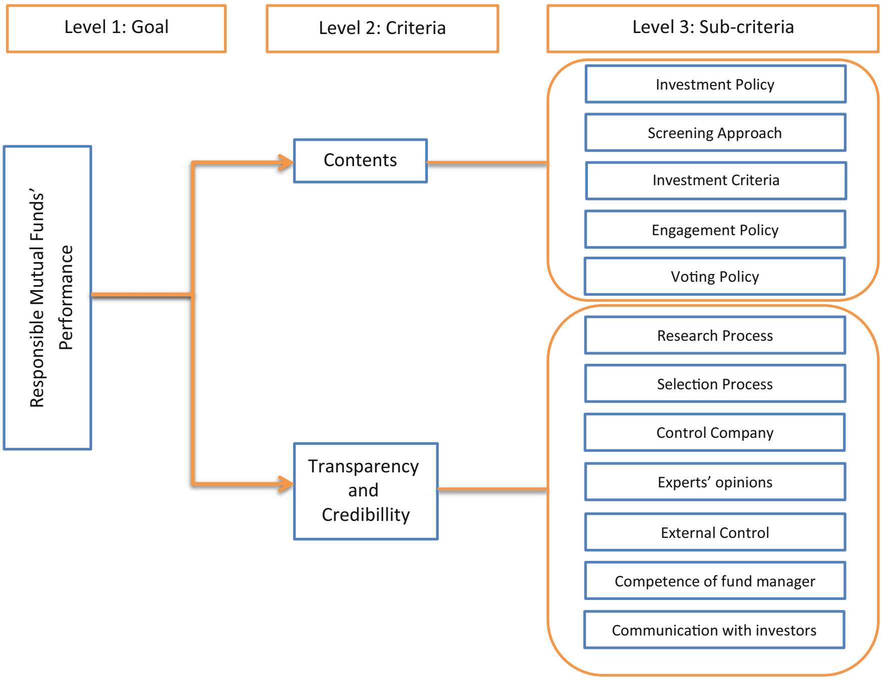


Fig. 12.1 First step on the AHP method: hierarchy structure

judgements about the relative values of the nodes in each level. Table 12.1 presents the preferences of the scale typically used in the AHP.

Table 12.2 shows the expert's judgements from the pairwise comparisons. Tables 12.3–12.5 present the preferences of the expert in a matrix format. For example, if we compare the importance of contents with transparency and credibility, the expert assigned a preference of three, indicating that the contents criterion has weakly more important than transparency and credibility.

Next step in the process is to calculate the consistency of the pairwise comparisons by using a technique suggested by Saaty (1977, 1980, 2001). Enforcing consistency is an important contribution of the AHP. By itself, a questionnaire cannot identify inconsistencies. According to Saaty (1994), "*The AHP can show one by one, in sequential order, which judgements are the most inconsistent, and also suggests the value that best improves consistency.*" By providing the expert an opportunity to re-examine preferences in a guided format, the AHP enables a better understand of the importance of the criteria. Saaty (1980) suggested that a consistency ratio value of 10 % or less is considered acceptable. Otherwise, it is recommended that the decision-maker revise the weight assignment to resolve inconsistencies in the pairwise comparisons.

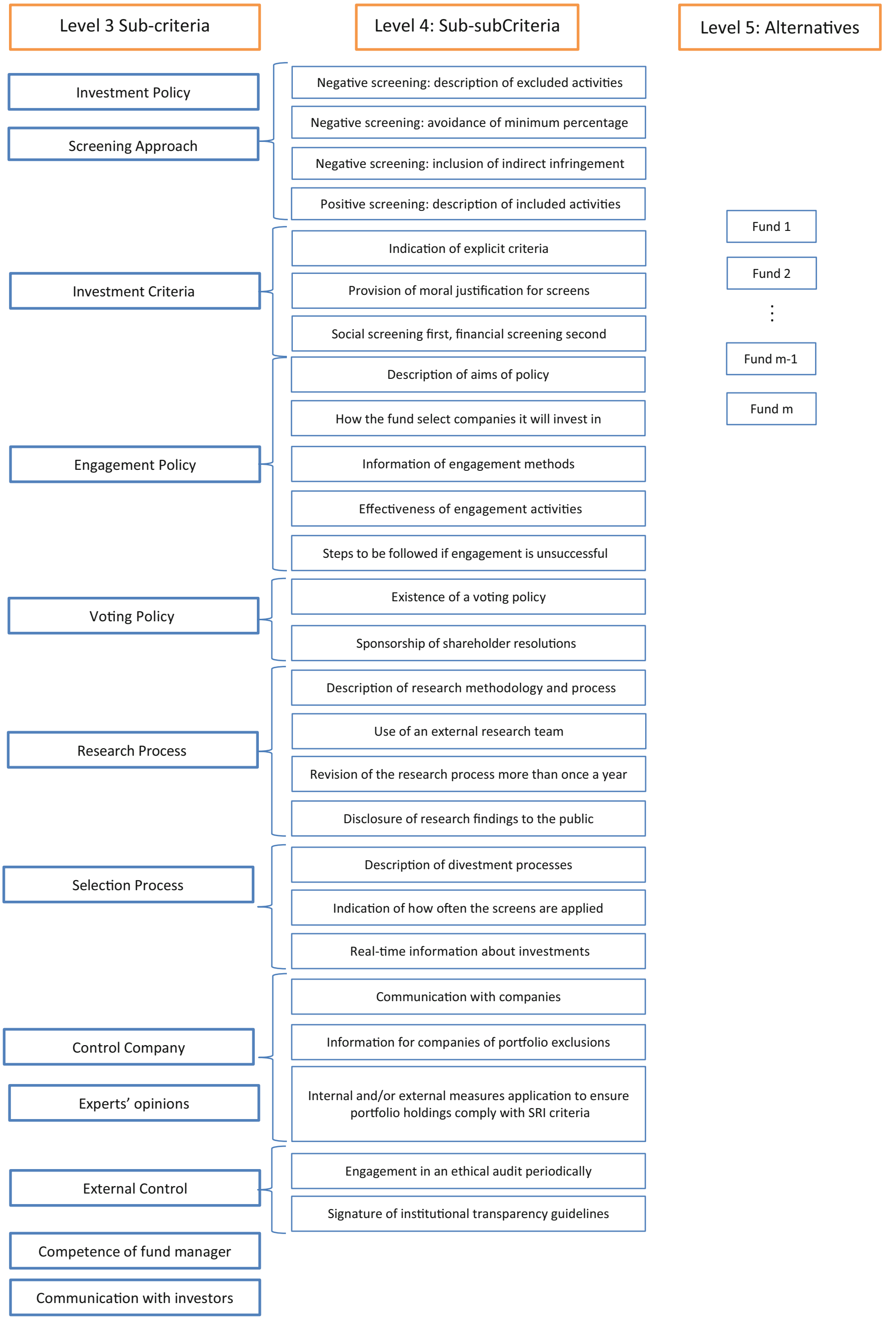


Fig. 12.2 First step on the AHP method: hierarchy structure (continued)

Table 12.1 Pairwise comparison scale

1	Equal importance	Two attributes contribute equally to the objective or goal
3	Moderate importance of one over another	Experience and judgement slightly favour one attribute over another
5	Essential or strong importance	Experience and judgement strongly favour one attribute over another
7	Very strong or demonstrated importance	An attribute is favoured very strongly over another; its dominance has been demonstrated in practice
9	Absolute or extreme importance	The evidence favouring one attribute over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between adjacent scale values	When compromised is needed

Source: Saaty 1980

The previously described steps can be programmed into a spreadsheet package or other mathematically-based software applications. However, there exist several commercial software packages that use AHP and provide the user computational accuracy, report generation, and graphic capabilities. In this work we choose to use the commercial package Expert Choice 11.5. This software program provides logical and powerful tools for comparing many alternatives when confronted with several conflicting criteria. Expert Choice, as a multicriteria decision support software tool based on AHP, allows incorporating in the model both, qualitative and quantitative information based on the experience and intuition of the decision maker and on hard data too. By incorporating both subjective judgements and objective data into the decision-making process, a more satisfactory solution can be realised (Expert Choice 2009).

Following tables display pairwise relative importance and consistency indices calculated with the software Expert Choice based on the expert's judgements. Process explained before is followed for obtaining the relative strengths of criteria in the fourth level with respect to criteria in the third level: After the consistency of the pairwise comparison matrix has been verified, the next step is to estimate the relative-importance weight of each criterion. Tables 12.3–12.6 show the relative-importance weights also calculated with Expert Choice. The most important

Table 12.2 Expert's judgements obtained from pairwise comparison

Criteria		More important	Intensity
A	B	(A or B)	(1–9)
Contents	Transparency and credibility	A	3
Investment policy	Screening approach	B	7
Investment policy	Investment criteria	B	3
Investment policy	Engagement policy	B	9
Investment policy	Voting policy	B	9
Screening approach	Investment criteria	A	5
Screening approach	Engagement policy	B	5
Screening approach	Voting policy	B	5
Investment criteria	Engagement policy	B	7
Investment criteria	Voting policy	B	7
Engagement policy	Voting policy	B	1
Research process	Selection process	A	1
Research process	Control of companies	A	1
Research process	Expert's opinion	A	3
Research process	External control	A	5
Research process	Competence of fund managers	A	3
Research process	Communication with investors	A	7
Selection process	Control of companies	B	5
Selection process	Expert's opinion	B	3
Selection process	External control	A	3
Selection process	Competence of fund managers	A	3
Selection process	Communication with investors	A	3
Control of companies	Expert's opinion	A	3
Control of companies	External control	A	3
Control of companies	Competence of fund managers	A	3
Control of companies	Communication with investors	A	3
Expert's opinion	External control	A	3
Expert's opinion	Competence of fund managers	A	3
Expert's opinion	Communication with investors	A	3
External control	Competence of fund managers	B	1
External control	Communication with investors	A	3
Competence of fund managers	Communication with investors	A	3

criterion for the expert is Contents, which is three times more important than transparency and credibility. If we explore the importance given by the expert to subcriteria related to the contents we can observe how engagement policy and voting policy have the same weight representing the highest importance with a weight three times the one assigned to the screening approach. If we consider subcriteria related to transparency and credibility, the more important criteria in the expert's opinion are the control of companies and the way the research is carried out, the research

Table 12.3 Analysis of pairwise relative importance of objectives from sample questionnaire

Comparison content subcriteria		
Preferred criteria	Contents	Transparency and credibility
Contents	1	3
Transparency and credibility	1/3	1
Relative importance of social responsible content subcriteria		
Weight	0.750	0.250
Consistency ratio		0.000

Table 12.4 Analysis of pairwise relative importance of objectives from sample questionnaire

Comparison content subcriteria					
Preferred criteria	Investment policy	Screening approach	Investment criteria	Engagement policy	Voting policy
Investment policy	1	1/7	1/3	1/9	1/9
Screening approach	7	1	5	1/5	1/5
Investment criteria	3	1/5	1	1/7	1/7
Engagement policy	9	5	7	1	1
Voting policy	9	5	7	1	1
Relative importance of social responsible content subcriteria					
Weight	0.028	0.140	0.051	0.390	0.390
Consistency ratio			0.08		

Table 12.5 Analysis of pairwise relative importance of objectives from sample questionnaire

Comparison transparency and credibility subcriteria							
Preferred criteria	Research process	Selection process	Control of companies	Expert's opinion	External control	Competency fund man.	Commu. investors
Research process	1	1	1	3	5	3	7
Selection process	1	1	1/5	1/3	3	3	3
Control of comp.	1	7	1	3	3	3	3
Expert's opinions	1/7	3	1/3	1	3	3	3
External control	1/5	1/3	1/3	1/3	1	1	3
Compet. fund man.	1/3	1/3	1/3	1/3	3	1	3
Commu. investors	1/7	1/3	1/3	1/3	1/3	1/3	1
Relative importance of social responsible transparency and credibility subcriteria							
Weight	0.260	0.115	0.279	0.161	0.075	0.070	0.040
Consistency ratio				0.09			

Table 12.6 Subcriteria relative strengths for each criterion

Criteria	Subcriteria	Weights
SA	Negative screening: description of excluded activities	0.084
	Negative screening: avoid of minimum percentages for screens	0.033
	Negative screening: inclusion of indirect infringement	0.008
	Positive screening	0.875
IC	Indication of explicit criteria	0.188
	Provision of moral justifications for screens	0.731
	Conduction of social screening first and then financial screening or viceversa	0.081
EP	Description of the aims of the policy	0.111
	Information about how the fund gives priority to which companies it will engage with	0.071
	Information of engagement methods	0.362
	Information of how effectiveness of engagement activities is monitored	0.198
	Information about what steps will be followed if engagement is unsuccessful	0.259
VP	The fund has a voting policy which practices and reasoning for decisions are displayed	0.750
	The fund sponsors shareholder resolutions	0.250
RP	Description of research methodology and process	0.114
	The fund manager uses a external research team	0.582
	Research process is revised more than once a year	0.205
	Disclosure of research findings to the public	0.099
SP	Description of policy and procedure for divestment on SRI grounds	0.109
	Indication of how often the screens are applied	0.309
	In real-time information about what companies the fund invests in	0.582
CC	Communication with companies to control for verification of selection criteria	0.634
	Information to companies of portfolio exclusions or divestments due to non-compliance with its SRI policy and criteria	0.174
	Internal and/or external measures application and display in place to ensure portfolio holdings comply with SRI criteria	0.192
EC	Engagement in an ethical audit periodically	0.750
	Signature of any institutional transparency guidelines (i.e., Eurosif guidelines)	0.250

Table 12.7 Equity mid-small cap mutual funds investment information (07-04-2009)

Fund's name		Principal investment sectors		
		Information (%)	Service (%)	Manufacturing (%)
AHA Socially Responsible Equity I	F1	12.69	42.00	45.31
Ariel Fund	F2	0	58.92	34.48
Calvert Small Cap Value Fund	F3	0	51.46	43.30
MMA Praxis Small Cap Fund	F4	19.07	55.85	25.09
Pax World Growth	F5	32.47	43.00	24.54

process. These two criteria's weight is more than twice that of the expert's opinion or the selection process.

The next step illustrates how to determine AHP could help the expert to rank mutual funds according to the previously considered multiple criteria.

12.2.2 Ranking Mutual Funds Based on Socially Responsible Criteria

In this model, the decision alternatives are the mutual funds we aim to rank. In order to illustrate the method proposed, we have chosen five US-based equity mid-small cap socially responsible mutual funds, which can be seen in Table 12.7.

A comparative qualitative database has been developed for the five mutual funds with the consideration of the identified criteria for socially responsible performance measurement. Table 12.8 shows the similarities and differences between the mutual funds in relation to the selection criteria and their ideal characteristics.

The suitability of the mutual funds under each socially responsible criterion is estimated by the expert using the empirical data provided by the SIF and Morningstar Ltd. In order to calculate each mutual fund's relative strength in serving the socially responsible criteria, first it is necessary to define the way each mutual fund characteristic is going to be measured. The measurement is based on a set of discrete (binary) and continuous variables (see Table 12.8). Binary variables are used for one-dimensional criterion. Zero indicates no satisfaction of the characteristic or dimension of the criterion, and 1 means total satisfaction of the characteristic or dimension of the criterion. Continuous variables have been used for those criteria presenting more than one dimension. We have used continuous variables which take values between zero and one, depending on the characteristics verified of the fund. Zero indicates no satisfaction of the characteristic or dimension of the criterion, 1 means total satisfaction of the characteristics or dimensions of this criterion, and intermediate values indicate intermediate levels of satisfaction of these criteria.

Table 12.8 AHP: Mutual funds' evaluation

Criteria	Subcriteria	Weights				
		F1	*F2*	*F3*	*F4*	*F5*
Investment policy		0	1	0	0	1
	Value	0	1	0	0	1
Screening approach	Negative screening: description of excluded activities	0.084	0.084	0.084	0.084	0.084
	Negative screening: avoid of minimum percentages for screens	0.033	0.033	0.033	0.033	0.033
	Negative screening: inclusion of indirect infringement	0	0	0	0	0
	Positive screening	0.875	0	0.875	0.875	0.875
	Value		0.117	0.992	0.992	0.992
Investment criteria	Indication of explicit criteria	0.188	0.188	0	0.188	0
	Provision of moral justifications for screens	0	0.731	0	0.731	0
	Conduction of social screening first and then financial screening	0.081	0	0	0.081	0
	Value	0.269	0.919	0	1	0
Engagement policy	Description of the aims of the policy	0	0	0	0.111	0
	Information about how the fund prioritises which companies it will engage with	0	0	0	0	0
	Information of engagement methods	0	0	0	0	0
	Information of how effectiveness of engagement activities is monitored	0	0	0	0	0
	Information about what steps will be follow if engagement is unsuccessful	0	0	0	0	0
	Value	0	0	0	0.111	0
Voting policy	The fund has a voting policy which is enforced and a reasoning for decisions is displayed	0.750	0.750	0.750	0.750	0.750
	The fund sponsors shareholder resolutions	0.250	0.250	0.250	0.250	0.250
	Value	1	1	1	1	1

(continued)

Table 12.8 (continued)

Criteria	Subcriteria	Weights				
		F1	*F2*	*F3*	*F4*	*F5*
Research process	Description of research methodology and process	0	0.114	0	0.114	0
	The fund manager uses an external research team	0.582	0.582	0	0.582	0
	Research process is revised more than once a year	0	0	0	0	0
	Research findings are disclosure to the public	0	0	0	0	0
	Value	0.582	0.696	0	0.696	0
Selection process	Description of policy and procedure for divestment on SRI ground	0	0.109	0	0.109	0
	Indication of how often the screens are applied	0	0	0	0	0
	In real-time information about what companies the fund invests in	0.582	0.852	0.582	0.582	0.582
	Value	0.582	0.691	0.582	0.691	0.582
Control of companies	Communications with companies to control for verification of selection criteria	0	0	0	0.634	0
	Information to companies of portfolio exclusions or divestments due to non-compliance with its SRI policy and criteria	0	0	0	0	0
	Internal and/or external measures application and display in place to ensure portfolio holdings comply with SRI criteria	0	0	0	0	0
	Value	0	0	0	0.634	0
Expert/s opinion		1	0	0	1	0
	Value	1	0	0	1	0
External control	Engagement in an ethical audit periodically	0	0	0	0.750	0
	Signature of any institutional transparency guidelines (i.e. Eurosif guidelines)	0	0.250	0	0.250	0
	Value	0	0.250	0	1	0
Competence of fund manager		0	1	0	1	0
	Value	0	1	0	1	0
Communication with investors		1	1	1	1	0
	Value	1	1	1	1	0

Table 12.9 Measurement of mutual fund characteristics

	Criteria											
Fund	IP	SA	IC	EP	VP	RP	SP	CC	EO	EC	CFM	CI
F1	0	0.992	0.269	0	0	1	0.582	0.582	0	0	0	1
F2	1	0.117	0.919	0	0	1	0.696	0.691	0	0	1	1
F3	0	0.992	0	0	0	1	0	0.582	0	0	0	1
F4	0	0.992	1	1	0.111	1	0.696	0.691	1	1	1	1
F5	1	0.992	0	0	0	1	0	0.582	0	0	0	1
	Normalised weights											
Fund	IP′	SA′	IC′	EP′	VP′	RP′	SP′	CC′	EO′	EC′	CFM′	CI′
F1	0	0.243	0.123	0	0	0.2	0.295	0.186	0	0	0	0.2
F2	0.500	0.029	0.420	0	0	0.2	0.353	0.221	0	0	0.5	0.2
F3	0	0.243	0	0	0	0.2	0	0.186	0	0	0	0.2
F4	0	0.243	0.457	1	1	0.2	0.353	0.221	1	1	0.5	0.2
F5	0.5	0.243	0.000	0	0	0.2	0	0.186	0	0	0	0.2

Source: SIF, Morningstar, Mutual Funds' Prospectuses

In this work we have decided to assign each variable a value corresponding to the weight of the dimension with respect to the criteria (see Table 12.6) but, as said before, continuous values from zero to one could be assigned depending on the degree of satisfaction of the characteristic. Table 12.8 display the criteria, their dimensions and the weights obtained from the expert's pairwise comparison using the Expert Choice 11.5 software.

Next, Table 12.9 shows the contribution of each characteristic to the criterion. As it can be observed, if we consider as a criterion the Screening Approach, seven aspects have to be evaluated: the type of screening (negative, positive or both) and, for those strategies including negative screening, we will also consider if the fund only provides a description of sectors and activities excluded from investment, if it avoids the use of minimum percentages for the screens and finally, if the fund includes indirect infringement of screens.

Once the contributions or weights are obtained from information provided by the expert, the quantitative measurement of the criterion is obtained by aggregating the weights of each characteristic on that criterion (see Table 12.8). Variables' values for each mutual fund are displayed in the Table 12.8 and summarised in the first panel of Table 12.9. In order to normalise the values in this table, we divide each element in a column by its column sum. The relative strength weights of the mutual funds in serving each criterion are also presented in Table 12.9. For example, under the criteria Screening Approach (SA), Ariel fund has the lowest weight, indicating that this fund is the less suitable investment for this particular criterion. But, if we consider the investment criteria, the highest weight corresponds to MMA Praxis Small Cap Value Fund followed by Ariel Fund.

Table 12.10 Mutual fund weights with respect to the criteria

Fund	Contents	Transparency
F1	0.040	0.146
F2	0.040	0.197
F3	0.034	0.112
F4	0.838	0.433
F5	0.048	0.112

Table 12.11 Mutual fund weights with respect to the goal

Fund	Weight	Ranking
F1	0.067	3
F2	0.079	2
F3	0.053	5
F4	0.737	1
F5	0.064	4
Overall inconsistency	0.08	

Once the relative importance of socially responsible criteria and strength of each mutual fund's contribution to each criterion have been determined, they are combined to obtain the mutual fund's weights. Table 12.10 displays the mutual funds weights with respect to the main criteria: contents and transparency and credibility.

As we can observe, the fund with the highest weight with respect to the socially responsible contents is MMA Praxis Small Cap Fund which is also the fund with the highest weight with respect to the transparency and credibility. But each of these criteria has a different contribution to the goal, i.e., the measurement of mutual funds socially responsible performance. Therefore, next step will consist on the calculation of the mutual funds' weights with respect to the goal, measurement of mutual funds socially responsible performance (SRIP) taking into account the relative contribution of the criteria:

$$SRIP = 0.75[0.028IP' + 0.14SA' + 0.051IP' + 0.39EP' + 0.39VP']+$$
$$+0.25[0.26RP' + 0.115SP' + 0.279SC' + 0.161EO'+$$
$$+0.075EC' + 0.07CFM' + 0.04CI']$$

These weights are calculated with the Expert Choice software and they are shown in Table 12.11. The mutual funds rating based on socially responsibility criteria and on the SRI expert's opinion are displayed in Table 12.12. This ranking is not only based on empirical data but also takes into account the relative importance that the expert gave to each socially responsible criterion. In Table 12.12, we have compared the obtained results using the AHP-based method with the ranking obtained using other proposed indices in academic literature and practice.

Table 12.12 Comparison of mutual funds socially responsible ranking using various indices

Fund name	Basso and Funari (2003)	Barnett and Salomon (2006)	Scholtens (2007)	Natural investment	AHP-based measure
F1	0.2	0.22	0.22	–	0.07
F2	0.2	0.05	0.08	0.16	0.08
F3	0.2	0.25	0.24	0.28	0.05
F4	0.2	0.25	0.26	0.28	0.74
F5	0.2	0.23	0.2	0.28	0.06
Weight	1	1	1	1	1

Table 12.12 displays the weights for the five mutual funds. The sum of weights for each index is one. As it can be observed, if an index of the kind proposed by Basso and Funari (2003) is used, all the funds will result equally ranked with respect to their social responsibility performance (see Chap. 4 for computational detail). Results for Barnett and Salomon (2006) and Scholtens (2007) are very similar and, in both cases, there are very small differences between funds ranked in the first, second, third and fourth position (0.01 points) and there is a great difference between these ones and the last fund ranked, which in both cases is the Ariel Fund. Natural Capital will rank the same funds for the first, second and third positions with similar weights than Barnett and Salomon and Scholtens, and it will rank Ariel Fund in the last position. Finally, the AHP-based method will agree with all previous indices and will rank MMA Praxis Small Cap Fund in the first position, but with an important difference in the weight assigned to this fund (0.74) and a difference of 0.66 points with respect to the second ranked fund.

It can be noted that four of the five revised methods rank in the first position the same fund. Nonetheless, the AHP-based method, which incorporates not only objective but also subjective information into the decision making process, is able to discriminate more between social responsible funds, identifying and weighting more those funds by means of verification of more dimensions of social responsibility. Although in all the cases the same fund is ranked in the first position, slight differences between this fund and the ones ranked in the second and third position exist when using non-AHP-based methods. Therefore, these methods will not assist the individual investor in identifying those funds which are, according to in the expert's opinion, really more social responsible.

12.3 Ranking SRI Mutual Funds Based on Macbeth

As mentioned in Sect. 12.1, we will concentrate on the US case. Two areas of concern can be identified when trying to evaluate socially responsible mutual funds. The first one corresponds to environmental, social and governance ("ESG") practices of companies invested in by the mutual funds (component 1) and the second one is “quality of the information” related to the managers’ investment policy (Hollingworth 1998), which considers contents, transparency and credibility of socially responsible information displayed in the prospectus of the mutual fund available to the general public (component 2). For each of these areas of concern, several dimensions and subdimensions have been defined to a total of 17 (see Figs. 12.3 and 12.4). The dimensions corresponding to “ESG” were obtained considering KLD’s methodology for their Corporate Social Ratings Monitor (KLD 2007) and taking into account information provided by the SIF and fund managers. Dimensions corresponding to the “quality of Information” were derived from a revision of literature and existing practice (Perez-Gladish and M’Zali 2010).

The tree showed in Figs. 12.3 and 12.4 was created in the MACBETH decision support system, considering the criteria in each dimension. The tree’s nodes, below its root node “Socially Responsible Mutual Funds Ranking”, correspond to the areas of concern when trying to rank socially responsible mutual funds. Five of the nodes are highlighted in red color indicating that they will be considered in this model, which are the socially responsible evaluation criteria we will consider for the evaluation of the mutual funds. Although the other nodes in the tree are not considered as criteria in this work, they have been included in order to enhance the model’s structure, thereby making it more intelligible and giving the reader a complete view of the problem. Therefore, the MACBETH tree is composed by two different types of nodes: criteria and non-criteria nodes.

12.3.1 Evaluation of Mutual Funds’ Socially Responsible Performance

Our set of alternatives or investment options is composed by a total of 25 U.S. domiciled large cap equity mutual funds. The mutual funds considered are all members of the SIF (see Tables 12.13 and 12.14 for details on the funds). Our universe is composed by seasonal funds (age equal or greater than 10 years). These funds have at least 70 % of assets in domestic stocks. In this study, we have considered large market capitalization funds belonging to growth or blend categories. *Growth funds* main goal is capital appreciation with little or no dividend payouts. *Blend funds* are funds with portfolios made up of a combination of value and growth stocks. *Value funds* are stock mutual funds that primarily hold stocks that are deemed to be undervalued in price and that are likely to pay dividends.

Since the same socially responsible investment strategy is usually followed by socially responsible mutual funds belonging to the same family, we have group them into families. In order to evaluate the socially responsible performance of each mutual fund family regarding each criterion, several attributes or requisites to be accomplished by the fund were defined (see Chap. 4). Besides, several performance levels were considered for each criterion depending on the total number of attributes

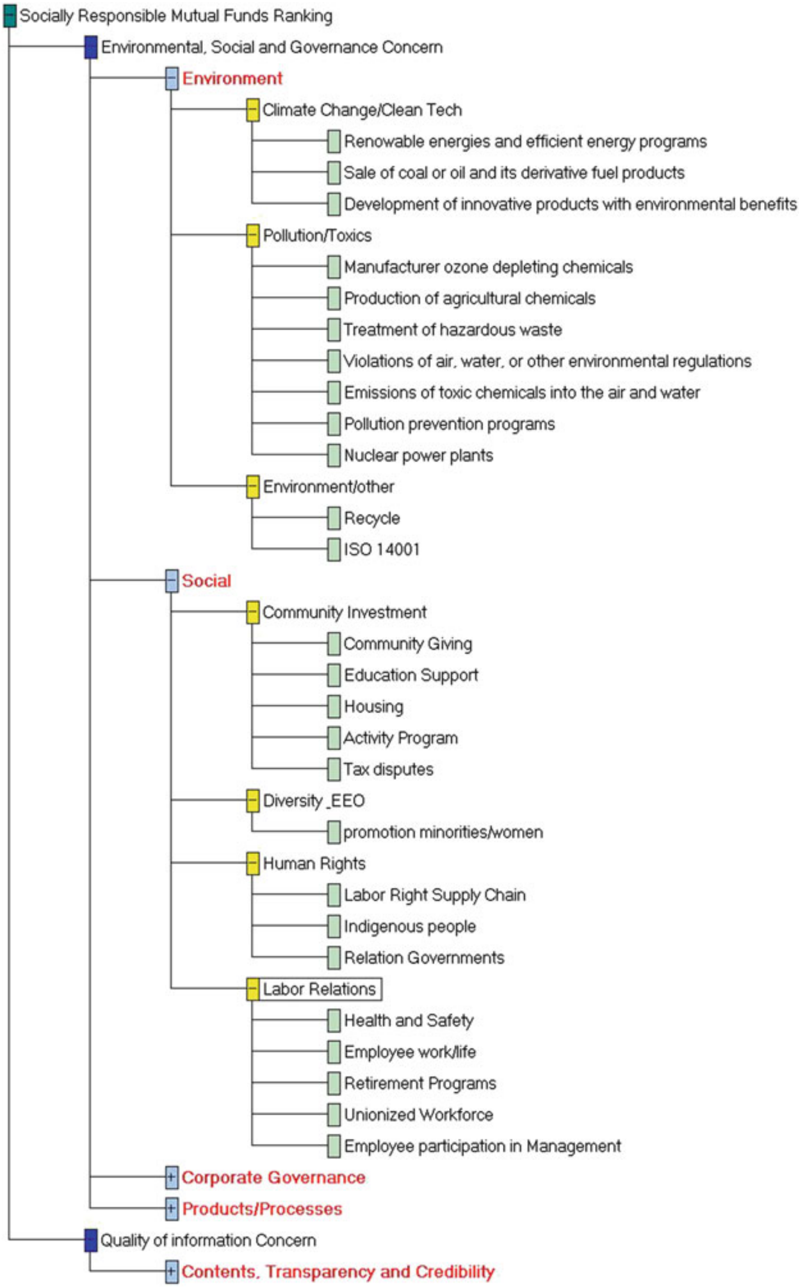


Fig. 12.3 MACBETH's value tree. Attributes describing the criteria (Part 1)

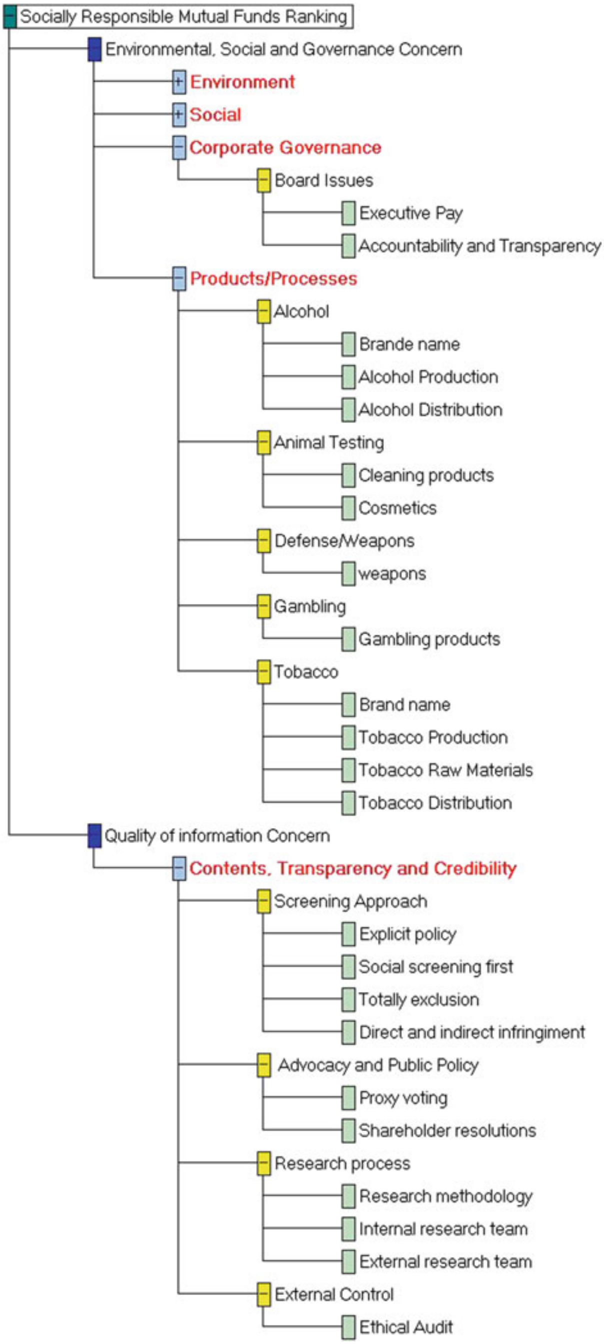


Fig. 12.4 MACBETH's value tree. Attributes describing the criteria (Part 2)

Table 12.13 MACBETH: US large cap equity mutual funds members of the SIF

Fund	Fund name	ISIN	Inception month/year	Morningstar category
F1	Calvert Large Cap Growth A	US13161P1021	08/94	US OE large growth
F2	Calvert Large Cap Growth B	US13161P2011	10/00	US OE large growth
F3	Calvert Large Cap Growth C	US13161P3001	10/00	US OE large growth
F4	Calvert Large Cap Growth I	US13161P4090	08/94	US OE large growth
F5	Calvert Large Cap Growth Y	US13161P7630	10/00	US OE large growth
F6	Calvert Social Index A	US1315827857	06/00	US OE large growth
F7	Calvert Social Index B	US1315827774	06/00	US OE large growth
F8	Calvert Social Index C	US1315827691	06/00	US OE large growth
F9	Calvert Social Index I	US1315827519	06/00	US OE large growth
F10	Calvert Social Investment Enhanced Equity A	US1316188036	04/98	US OE large blend
F11	Calvert Social Investment Enhanced Equity B	US1316188861	04/98	US OE large blend
F12	Calvert Social Investment Enhanced Equity C	US1316188788	06/98	US OE large blend
F13	Calvert Social Investment Equity A	US1316183086	08/87	US OE large growth
F14	Calvert Social Investment Equity B	US1316188523	03/98	US OE large growth
F15	Calvert Social Investment Equity C	US1316187046	03/94	US OE large growth
F16	Calvert Social Investment Equity I	US1316187954	11/99	US OE large growth
F17	Domini Social Equity I	US2571321007	06/91	US OE large blend
F18	Green Century Equity	US3927683058	06/91	US OE large blend
F19	MMA Praxis Core Stock Fund A	US5530784033	05/99	US OE large blend
F20	Neuberger Berman Socially Resp Inv	US6412246059	03/94	US OE large blend

(continued)

Table 12.13 (continued)

Fund	Fund name	ISIN	Inception month/year	Morningstar category
F21	Neuberger Berman Socially Resp Tr	US6409178604	03/97	US OE large blend
F22	Parnassus Equity Income Fund	US7017691012	08/92	US OE large blend
F23	Parnassus Fund	US7017651099	12/84	US OE large growth
F24	Sentinel Sustainable Core Opportunities Fund	US81728B7266	06/96	US OE large blend
F25	Walden Social Equity Fund	US9128804088	06/99	US OE large growth

Source: Morningstar Ltd.

describing the criteria. For example, the "Environmental" criterion has 12 main attributes or requisites, which are grouped into 3 areas of concern: "Climate Change and Clean Technologies", "Pollution and Toxics" and "Other Environmental". The performance levels for "Climate Change and Clean Technologies" identified after interviewing mutual funds' managers and current practice were:

- The fund invests in companies that have taken significant measures to reduce the contributions of their operations to global climate change and air pollution through the use of renewable energy, other clean fuels, or through the introduction of energy efficient programs or sale of products promoting energy efficiency.
- The funds avoid investing in companies which derive revenues from the sale of coal or oil and its derivative fuel products.
- The fund invests in companies which derive substantial revenues from the development of innovative products with environmental benefits, including remediation products, environmental services, or products that promote the efficient use of energy.

Seven performance levels were selected for "Pollution and Toxics":

- The fund avoids investing in companies which manufacturer ozone depleting chemicals such as HCFCs, methyl chloroform, methylene chloride, or bromine.
- The fund avoids investing in companies which are substantial producer of agricultural chemicals, including pesticides.
- The fund avoids investing in companies which have substantial liabilities for hazardous waste, or has recently paid significant fines or civil penalties for waste management violations.
- The fund avoids investing in companies which have recently paid substantial fines or civil penalties for, or it have a pattern of controversies regarding, violations of air, water, or other environmental regulations.
- The fund avoids investing in companies whose emissions of toxic chemicals into the air and water from individual plants are notably high.

Table 12.14 MACBETH: Mutual funds' sector composition

Funds	Sector composition (%)												
	Software	Hardware	Media	Telecom	Healthcare	Consumer services	Business services	Financial services	Consumer goods	Industrial materials	Energy	Utilities	Total
F1–F5	4.63	17.77	5.07	7.30	11.81	20.65	1.75	5.70	12.64	5.82	6.85	0.00	100
F6–F9	6.58	14.53	3.14	10.93	11.96	10.48	4.60	15.60	10.68	7.13	3.49	0.87	100
F10–F12	3.88	10.12	5.94	4.24	12.99	16.25	1.57	12.04	6.78	9.75	9.35	7.08	100
F13–F16	7.80	8.51	0.00	8.32	11.60	22.93	5.20	13.16	3.67	7.37	11.43	0.00	100
F17	5.68	13.83	1.56	6.62	10.38	10.57	1.77	17.60	12.78	5.85	10.69	2.69	100
F18	5.77	11.87	1.93	8.76	16.18	11.45	4.61	14.72	9.78	7.65	5.66	1.62	100
F19	1.37	2.71	0.85	5.18	11.79	11.74	4.97	29.03	13.91	5.78	12.67	0.00	100
F20–F21	3.24	7.68	4.95	3.70	15.48	10.09	3.03	18.60	10.71	10.00	12.53	0.00	100
F22	5.68	5.10	0.00	11.02	9.83	2.54	6.89	18.53	7.41	15.69	14.31	3.02	100
F23	9.36	15.65	0.78	20.71	9.12	7.60	2.03	16.10	0.00	12.89	5.76	0.00	100
F24	5.07	10.60	7.24	3.28	14.54	2.62	5.27	14.64	10.56	9.21	14.41	2.58	100
F25	4.45	7.42	3.74	2.07	14.38	11.85	7.44	12.93	9.03	14.43	12.25	0.00	100

- The fund invests in companies which have strong pollution prevention programs, including both emissions and toxic-use reduction programs.
- The fund avoids investing in companies which are owners or operators of nuclear power plants, excluding electric utility co's.

And finally, for "Other Environmental", two performance level were considered:

- The fund invests in companies that are either a substantial user of recycled materials in its manufacturing processes, or major firms in the recycling industry.
- The fund invests in companies that have demonstrated a superior commitment to management systems through ISO 14001 certification and other voluntary programs.

Non-numerical approaches, such as MACBETH, can be used for measuring the relative value of the options in each criterion. In the MACBETH approach, a criterion node should be always associated with a "basis of comparison", either a direct or an indirect one (see http://www.m-macbeth.com/downloads.html). Here, we will use an indirect basis of comparison: "quantitative performance levels", which will let us evaluate the mutual funds' relative attractiveness indirectly, through the use of a value function that will convert any mutual fund's performance on the criterion into a numerical score. Regarding the "Environment" criterion, 13 performance levels have been considered: from 0 to 12. For the "Social" criterion, 17 performance levels have been considered: from 0 to 16. In relation to the "Governance" criterion, 3 performance levels: from 0 to 2. And, for "Products/Processes" criterion, 12 performance levels have been used: from 0 to 11. These performance levels represent the possible number of attributes that could be verified by a fund.

Unfortunately, no public quantitative information is available about mutual funds' performance level in each of the above criteria. Information about accomplishment of SRI criteria provided by mutual funds' managers is very general and, in most of the cases, it is vague or imprecise. Through a careful study of the information was carried out, each mutual fund was evaluated with respect to the previous attributes using a binary variable, for which 0 means that the attribute is not verified and 1 indicates that the attribute is verified. We could no considered different compliance degrees due to the lack of available information (see Table 12.15).

In this work, equal importance is supposed for each attribute within a certain criterion. We obtained mutual funds' performance in each criterion by adding the scores reached in the corresponding attributes (technical details on computation can be provided to the reader upon request). Let us consider the "Social" criterion. A performance level equal to 0 means that the fund does not accomplish any of the requisite describing that criterion, and a performance level equal to 16 means that the fund screens for all the attributes considered in the criterion.

Two (fictitious) reference profiles are defined with respect to each criterion: an anti-ideal and ideal mutual fund. An *ideal fund* is a fund which has all the considered

Table 12.15 MACBETH: Mutual funds' socially responsible performance and reference profiles for each socially responsible criterion (Own Source)

Funds	Criteria				
	Environment	Social	Governance	Product	Quality of information
F1	3	5	2	6	4
F2	3	5	2	6	4
F3	3	5	2	6	4
F4	3	5	2	6	4
F5	3	5	2	6	4
F6	3	5	2	6	4
F7	3	5	2	6	4
F8	3	5	2	6	4
F9	3	5	2	6	4
F10	3	5	2	6	4
F11	3	5	2	6	4
F12	3	5	2	6	4
F13	3	5	2	6	4
F14	3	5	2	6	4
F15	3	5	2	6	4
F16	3	5	2	6	4
F17	3	10	1	6	6
F18	4	7	0	9	5
F19	4	3	0	11	4
F20	4	3	0	11	4
F21	4	3	0	11	4
F22	3	4	2	11	7
F23	3	4	2	11	7
F24	6	6	2	10	4
F25	10	6	2	7	8
Ideal	**12**	*14*	**2**	**11**	**10**
Anti-ideal	**0**	**0**	**0**	**0**	**0**

socially responsible attributes in one criterion. An *anti-ideal fund* is a fund that has no attributes at all in a certain socially responsible criterion (see Table 12.15).

12.3.2 Weighting the Evaluation Criteria

In order to measure how attractive (or unattractive) each mutual fund is for each criterion, a 0–100 cardinal value function was built. A value function allows translating performance levels into value scores, so that it can indicate the attractiveness relative to each other of the performance levels or impacts within a criterion. In doing so, MACBETH approach adopted the additive value aggregation model (Belton 1999).

Let $C^\star = \{1, \ldots, 5\}$ be the set of all criteria. For each $j \in C^\star$, the investor will be able to order all mutual funds on issue j taking into account the attractiveness of these funds on the given issue or criterion. For that, for each criterion $j \in C^\star$, the investor will be asked to verbally judge the difference of attractiveness between each to mutual funds f_j and f'_j, where f_j is at least as attractive to the investor as f'_j. When judging, the investor will have to choose one of the following categories:

C_0 no difference of attractiveness.
C_1 very weak difference of attractiveness.
C_2 weak difference of attractiveness.
C_3 moderate difference of attractiveness.
C_4 strong difference of attractiveness.
C_5 very strong difference of attractiveness.
C_6 extreme difference of attractiveness.

If the investor is not sure about the difference of attractiveness, it may choose the union of several categories among these above. Furthermore, when comparing to funds on a given criterion, an answer "I do not know" is acceptable and it will appear in the MACBETH software as "positive difference of attractiveness".

For each criterion $j \in C^\star$,the MACBETH software allows to associate to each fund f_j a real number $U_j(f_j)$ which, in the particular case where there is no hesitation about the difference of attractiveness, satisfies the following rules (see Bana e Costa et al. 2003):

$$\forall j \in C^\star, \forall f_j, f'_j : U_j(f_j) > U_j(f'_j) \Leftrightarrow f_j \text{ is more attractive than} f'_j,$$

$$\forall j \in C^\star, \forall k, k' \in \{1,2,3,4,5,6\}, \forall f_j, f'_j, f''_j, f'''_j \text{ with}(f_j, f'_j) \in C_k$$

$$\text{and}(f''_j, f'''_j) \in C'_k : k \geq k' + 1 \Rightarrow U_j(f_j) - U_j(f'_j) > U_j(f''_j) - U_j(f'''_j)$$

This numerical scale is essentially obtained by linear programming and it is called the MACBETH basic scale. The MACBETH scale exists if and only if it is possible to satisfy previous rules. In such a case, the matrix of judgements is called *consistent*. If it is not possible, MACBETH software provides a tool to obtain a consistent matrix of judgements.

The basic MACBETH scale, as well as each scale obtained by a positive linear transformation, is a *pre-cardinal* scale. In order to obtain a *cardinal* scale, a discussion with the investor in question around the scale will take place. MACBETH allows investor to modify the position of a selected fund on a given criterion in a graphical representation of the value scale called *thermometer*. The investor will be able to modify the position of a fund if he/she beliefs that the relative distances between the funds on the criterion do not reflect the relative distances on attractiveness that the investor deems to exist between the funds on the given criterion. When the investor thinks that the scale finally represents the relative magnitude of the judgements, we have the cardinal scale and the final values of all policies on the given criterion.

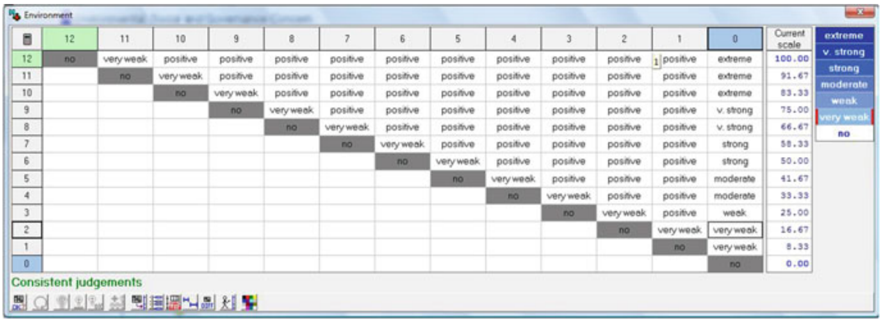
Let $v_j(f_j)$ be the value of mutual fund f on the j-th criterion. The $upper_j$ and $lower_j$ are respectively the ideal and anti-ideal impact levels for the j-th criterion, and k_j is the scaling constant for the j-th criterion. In order to measure the global attractiveness of each fund with respect to all the criteria simultaneously, denoted by $V(f)$,the following aggregating procedure will be adopted (see Bana e Costa et al. 2003 and Roubens et al. 2006):

$$V(f) = \sum_{j=1}^{5} w_j v_j(f_j), \text{ with} \sum_{j=1}^{5} w_j = 1$$

$$\text{and } w_j > 0 \text{ for } j = 1, \ldots 5, \text{ and } v_j(upper_j) = 100, v_j(lower_j) = 0.$$

The value functions for evaluating performance levels within the descriptor of each criterion are obtained in the same way. They are anchored in the lower and upper reference levels previously defined.

Going back to our problem, let us consider the "Environment" criterion. The investor was asked to compare the upper and lower performance levels for this criterion (12 and 0, respectively). The process continued with qualitative judgements for the second most attractive performance level with the least attractive performance level, and so on, completing the last column in the table shown in Fig. 12.5. The most attractive level was then compared to each of the other levels, in order of increasing attractiveness, thereby completing the first row of the matrix, now taking as the fixed reference the most attractive level, 3. The next step consisted of comparing the most attractive level with the second most attractive level, the second most attractive with the third, and so on, thereby completing the diagonal border of the upper triangular portion of the matrix (Bana e Costa et al. 2003). Table shown in Fig. 12.5 provides the judgement matrix obtained for the "Environment" criterion. In this table, "positive" means that the difference in attractiveness has not



	12	11	10	9	8	7	6	5	4	3	2	1	0	Current scale
12	no	very weak	positive	positive	positive	positive	positive	positive	positive	positive	positive	positive	extreme	100.00
11		no	very weak	positive	positive	positive	positive	positive	positive	positive	positive	positive	extreme	91.67
10			no	very weak	positive	positive	positive	positive	positive	positive	positive	positive	extreme	83.33
9				no	very weak	positive	positive	positive	positive	positive	positive	positive	v. strong	75.00
8					no	very weak	positive	positive	positive	positive	positive	positive	v. strong	66.67
7						no	very weak	positive	positive	positive	positive	positive	strong	58.33
6							no	very weak	positive	positive	positive	positive	strong	50.00
5								no	very weak	positive	positive	positive	moderate	41.67
4									no	very weak	positive	positive	moderate	33.33
3										no	very weak	positive	weak	25.00
2											no	very weak	very weak	16.67
1												no	very weak	8.33
0													no	0.00

Fig. 12.5 Investor's matrix of judgements for the performance levels in criterion "Environment"

been qualified specifically by the investor, but due to the way the descriptor of the criterion was constructed, this difference of attractiveness is automatically positive.

After expert's quality judgements have been obtained, MACBETH software checks for inconsistency (see Bana e Costa and Vansnick 1999). Once the judgements matrix is consistent, MACBETH software proposes a value scale based on linear programming, which is normalized with the anti-ideal level at 0 and the ideal level at 100. The value function displays the differences of value corresponding to the investor's qualitative judgements (see Fig. 12.6). In order to obtain a value scale for the "Environment" criterion, the interval scale defined on 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 is extended by the software to the full range of continuous descriptors of "Environment" by linear interpolation, giving rise to value function, v_1.

Before moving on to the next step, the value scale proposed by MACBETH is presented to the investor to ensure that it represents the relative magnitude of the investor's judgements in a suitable way. For this, the thermometer scale is shown to the investor, who is requested to visually compare proportions between the intervals (differences of values). The investor agreed with the value scale proposed by MACBETH as she considered that each unitary marginal increment

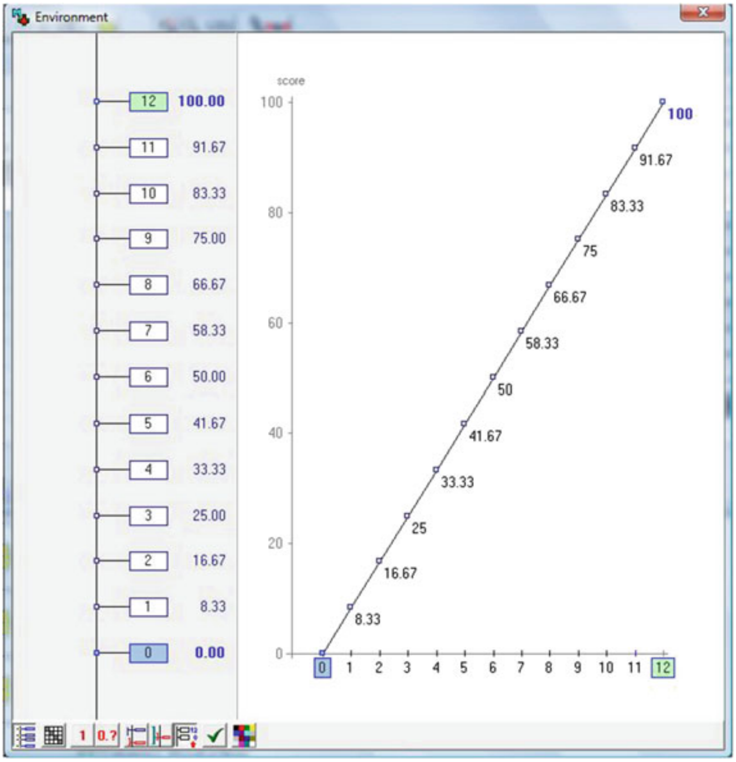


Fig. 12.6 Value function of "Environment" (v_1)

Table of scores

Options	Overall	1.1 Environmen	1.2 Social	1.3 Governance	1.4 Products	2.1
F1	?	25.00	35.71	100.00	58.33	40.00
F2	?	25.00	35.71	100.00	58.33	40.00
F3	?	25.00	35.71	100.00	58.33	40.00
F4	?	25.00	35.71	100.00	58.33	40.00
F5	?	25.00	35.71	100.00	58.33	40.00
F6	?	25.00	35.71	100.00	58.33	40.00
F7	?	25.00	35.71	100.00	58.33	40.00
F8	?	25.00	35.71	100.00	58.33	40.00
F9	?	25.00	35.71	100.00	58.33	40.00
F10	?	25.00	35.71	100.00	58.33	40.00
F11	?	25.00	35.71	100.00	58.33	40.00
F12	?	25.00	35.71	100.00	58.33	40.00
F13	?	25.00	35.71	100.00	58.33	40.00
F14	?	25.00	35.71	100.00	58.33	40.00
F15	?	25.00	35.71	100.00	58.33	40.00
F16	?	25.00	35.71	100.00	58.33	40.00
F17	?	25.00	71.43	50.00	58.33	60.00
F18	?	33.33	50.00	0.00	83.33	50.00
F19	?	33.33	21.43	0.00	100.00	40.00
F20	?	33.33	21.43	0.00	100.00	40.00
F21	?	33.33	21.43	0.00	100.00	40.00
F22	?	25.00	28.57	100.00	100.00	70.00
F23	?	25.00	28.57	100.00	100.00	70.00
F24	?	50.00	42.86	100.00	91.67	40.00
F25	?	83.33	42.86	100.00	66.67	80.00
[all upper]	?	100.00	100.00	100.00	100.00	100.00
[all lower]	?	0.00	0.00	0.00	0.00	0.00
Weights :		?	?	?	?	?

Fig. 12.7 Mutual funds' scores in the criteria

on the number of attributes has the same attractiveness. That is, the difference in attractiveness between 2 and 1 attributes verified by a fund is equal to the difference in attractiveness between 3 and 2, which is equal to the difference in attractiveness between 4 and 3, and so on. This process was followed with the other four criteria.

With the value functions, the impacts of each mutual fund could then be translated into value scores, as shown in Fig. 12.7. Weights were assessed with reference to the impact ranges of the attributes, based on MACBETH judgements. We have followed the steps proposed by Bana e Costa et al. (2003). As both, the upper and the lower reference levels, had been previously determined, the first question asked to the investor was: "*Let us consider the fictitious anti-ideal fund, which has a lower performance in every the criterion; how much would a swing from neutral to good environment performance increase its overall attractiveness?*" The investor was invited to answer with a MACBETH qualitative judgement and similar questions were subsequently asked for each of the other three criteria, completing the last column of the "judgement weighting matrix" (Fig. 12.7). From this table, we can obtain a ranking of mutual funds with respect to each criterion, which are shown in Fig. 12.8.

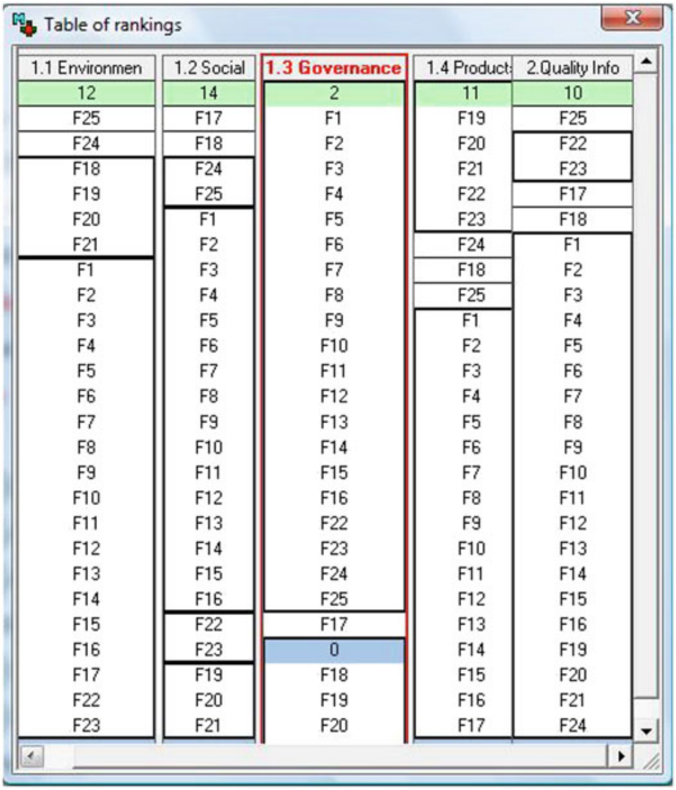


Table of rankings

1.1 Environmen	1.2 Social	1.3 Governance	1.4 Product	2.Quality Info
12	14	2	11	10
F25	F17	F1	F19	F25
F24	F18	F2	F20	F22
F18	F24	F3	F21	F23
F19	F25	F4	F22	F17
F20	F1	F5	F23	F18
F21	F2	F6	F24	F1
F1	F3	F7	F18	F2
F2	F4	F8	F25	F3
F3	F5	F9	F1	F4
F4	F6	F10	F2	F5
F5	F7	F11	F3	F6
F6	F8	F12	F4	F7
F7	F9	F13	F5	F8
F8	F10	F14	F6	F9
F9	F11	F15	F7	F10
F10	F12	F16	F8	F11
F11	F13	F22	F9	F12
F12	F14	F23	F10	F13
F13	F15	F24	F11	F14
F14	F16	F25	F12	F15
F15	F22	F17	F13	F16
F16	F23	0	F14	F19
F17	F19	F18	F15	F20
F22	F20	F19	F16	F21
F23	F21	F20	F17	F24

Fig. 12.8 Table of rankings on each criterion

We can observe how mutual funds' rank changes depending on the considered criterion. For "Environment", "Social", "Products" and "Quality of Information", all mutual funds performed better than the fictitious anti-ideal fund. Fund 25 is the best with respect to "Environment" and "Governance". Fund 17 is the best with respect to the "Social" criterion. Besides, three funds are ranked below the anti-ideal fund, funds 18, 19 and 20 for the "Governance" criterion.

The next step was to elicit weights from the investor for the five criteria considered. First, she ordered the criteria from more to least attractive (Governance, Environment, Social, Quality of Information and Products) and, subsequently, she directly assigned weights based on statistics for SIF members displayed in Fig. 12.6. It is interesting to observe how the main concern of the members of the SIF was in corporate governance, followed by environmental issues, social issues and, at last, controversial related products and industries. This fact shows an evolution in the values of investors from the decade of the 1970 when the main socially responsible investment strategy was exclusion of investments in certain controversial industries (see Fig. 12.9).

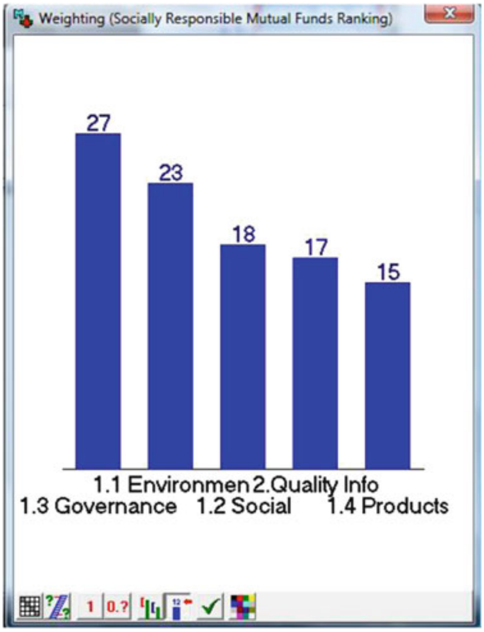


Fig. 12.9 Criteria weights

Figure 12.10 shows in the overall column the overall attractiveness of the mutual funds and of the profiles "ideal" and "anti-ideal" (ranked by order of decreasing attractiveness). In the last four columns, the scales v_1, v_2, v_3 and v_4 are presented. The respective weights of the criteria appear in the last line. Finally, Fig. 12.11 displays the overall mutual funds' ranking.

Mutual fund 25, Walden Social Equity Fund is, with difference, the most socially responsible fund, followed by funds 24, 22 and 23. Calvert funds go next, followed by funds 17, 18, 19, 20 and 21. The most environmental responsible mutual fund is also mutual fund 25, which is also the best with respect to the quality of the information provided by the mutual fund manager in the website or mutual fund's prospectus. Nevertheless, this fund is not the best if we consider social issues or when we consider involvement of the fund with the traditional controversial industries, as tobacco, alcohol, pornography … Mutual fund 25 invests primarily in the Service and Manufacturing Sectors (more than 80 % of its assets are involved with this sectors). The fund invests 14.41 % in healthcare industries, 12.68 % in financial services companies, 15.78 % in consumer goods manufacturing companies, 13.17 % in companies involved with industrial materials and 11.61 % in the energy sector. This sectors are traditionally more or less environmental responsible.

Table of scores

Options	Overall	1.1 Environmen	1.2 Social	1.3 Governance	1.4 Products	2.Quality Info
F1	54.73	25.00	35.71	100.00	58.33	40.00
F2	54.73	25.00	35.71	100.00	58.33	40.00
F3	54.73	25.00	35.71	100.00	58.33	40.00
F4	54.73	25.00	35.71	100.00	58.33	40.00
F5	54.73	25.00	35.71	100.00	58.33	40.00
F6	54.73	25.00	35.71	100.00	58.33	40.00
F7	54.73	25.00	35.71	100.00	58.33	40.00
F8	54.73	25.00	35.71	100.00	58.33	40.00
F9	54.73	25.00	35.71	100.00	58.33	40.00
F10	54.73	25.00	35.71	100.00	58.33	40.00
F11	54.73	25.00	35.71	100.00	58.33	40.00
F12	54.73	25.00	35.71	100.00	58.33	40.00
F13	54.73	25.00	35.71	100.00	58.33	40.00
F14	54.73	25.00	35.71	100.00	58.33	40.00
F15	54.73	25.00	35.71	100.00	58.33	40.00
F16	54.73	25.00	35.71	100.00	58.33	40.00
F17	51.06	25.00	71.43	50.00	58.33	60.00
F18	37.67	33.33	50.00	0.00	83.33	50.00
F19	33.32	33.33	21.43	0.00	100.00	40.00
F20	33.32	33.33	21.43	0.00	100.00	40.00
F21	33.32	33.33	21.43	0.00	100.00	40.00
F22	64.79	25.00	28.57	100.00	100.00	70.00
F23	64.79	25.00	28.57	100.00	100.00	70.00
F24	66.77	50.00	42.86	100.00	91.67	40.00
F25	77.48	83.33	42.86	100.00	66.67	80.00
[all upper]	100.00	100.00	100.00	100.00	100.00	100.00
[all lower]	0.00	0.00	0.00	0.00	0.00	0.00
Weights :		0.2300	0.1800	0.2700	0.1500	0.1700

Fig. 12.10 Value table

12.4 Discussion

MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) and AHP (Analytic Hierarchy Process) are two effective tools which provide aid to the decision maker in order to set priorities and make best decisions when dealing with complex decision making.

Although MACBETH and AHP have numerous elements in common, there are several relevant differences not only in the taxonomy but also in the way main phases are managed. We can find significant changes as much from the structuring stage as from the evaluation stage in the way the process is ran. For example, we find key divergences in the scale used in the judgements and in the judgements validations.

A comparison of the use of AHP and MACBETH can be found in Schmidt (1995). This work focused on how to improve the competitiveness of the Graduation Program of Industrial Engineering at the Universidad Federal de Santa Catarina. The AHP model included three criteria such as research qualification, society contribution and competitive formation and seven alternatives. The alternatives being lessons quality, infrastructure, professor's quality, thesis evaluation, benefits to study, number of incoming students and name of the program. According to the

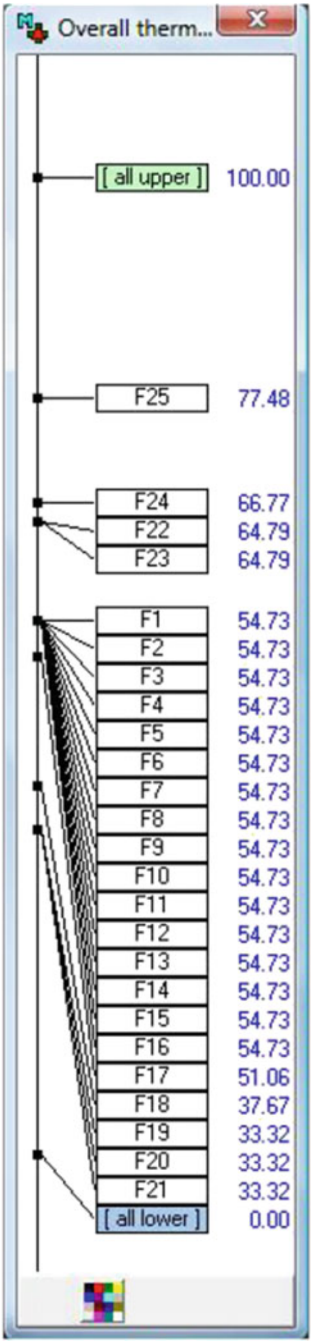


Fig. 12.11 Overall thermometer

results obtained after applying AHP, among the alternatives, the most relevant one came to be “infrastructure”. And this alternative only got replaced when criteria “competitive formation” weighted close to 80 %. At that level, alternative “thesis evaluation” became the most relevant. When applying MACBETH to the same case, a complete different picture was shown, since the alternatives selected were “consulting and services”, “training courses to the community” and “infrastructure”. Surprisingly, two out of three of the top ranked alternatives were not in the starting list for the AHP application. Schmidt (1995) did not mention if the judgements for the MACBETH case, were done by the same set of students than for the AHP analysis. This implies that the divergence of the results cannot be generalized. As long as no further comparative works were performed, this research is unique and further work should be done in this field.

Conclusions

The aim of this chapter was to describe, for a given financial performance, two ranking methods for mutual funds based on their socially responsible performance. The main motivation is that these ranking methods could allow individual and institutional investors to select their mutual funds taking into account their ethical values.

MCDA techniques are suitable tools for this purpose, since they enable us to explore and to introduce into the model the multiple dimensions of mutual funds’ social responsibility. Because of this, the two method described apply two MCDA techniques to obtain an indicator for mutual funds based on their social responsibility. On the one hand, the AHP method has been considered, which has enabled us to take into account several social responsibility dimensions in order to rank socially responsible mutual funds. It has been shown that using AHP for the analysis of the social responsibility of mutual funds can be of great help for the selection of a suitable socially responsible mutual fund portfolio. On the other hand, we have used MACBETH, which is an interactive methodology based on semantic judgements about the differences in attractiveness of several options. The application of this approach has allowed us to help individual investors, since it has provided them with a ranking for socially responsible mutual funds based on their particular preferences.

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Chapter 13
Portfolio Selection with SRI Synthetic Indicators: A Reference Point Method Approach

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Abstract In this chapter we present an individual investment decision making tool for stocks' portfolio selection taking into account the subjective and individual preferences about different financial and socially responsible features of a particular investor. In order to do so, the first problem to be solved is the measurement of the degree of social responsibility of a financial asset. In this work we use a double reference point scheme to obtain synthetic indicators of the social responsibility degree of stocks. Then, a mixed reference point classification scheme is used to solve the resulting multiple criteria portfolio selection model including, together with the classical financial criteria, a social responsibility criterion based on the synthetic social indicators previously obtained. In order to illustrate the suitability and applicability of the proposed investment decision making model, an empirical study on a set of Spanish domiciled stocks is presented.

13.1 Introduction

As we have seen in the first part of this book, the current long economic recession has affected all dimensions of the world economy and the asset management industry has not been immune to these negative impacts. In Chap. 2 we have described the situation of the Spanish financial market which has not been an exception. The overall asset management market in Spain has seen total assets under management reduce considerably over the past several years, due to, firstly, contagion effects from the global financial crisis of 2007–2008. Moreover, another reason for that have been the corrections experienced in the overheated local housing and commercial real estate market. For instance, an according to the latest published

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available data, the total assets under management of the broader Spanish asset management industry have declined by over 31 % since their peak in 2007, when total assets under management reached 414.6 billion euros. The downward trend has continued over the past year as total assets declined by an additional 6 % to reach 284.7 billion euro at the close of 2011 Eurosif (2012).

Nevertheless, and despite this very difficult economic context, the Socially Responsible Investing (SRI) market is gaining popularity.

In this chapter we present a model which is intended to be an individual investment decision making tool for stocks' portfolio selection taking into account the subjective and individual preferences about different financial and socially responsible features of a particular investor. With this aim we first propose the use a double reference point scheme to obtain synthetic indicators of the social responsible degree of the stocks, as suggested in Cabello et al. (2014). Then, we model a multiple criteria portfolio selection model including, together with the classical financial criteria, a non-financial criterion related with the social responsibility of the portfolio, based on the synthetic social indicators previously obtained.

In order to solve the portfolio selection problem, an interactive mixed reference point classification scheme is proposed. This scheme is aimed at providing a flexible decision making environment for the investor, ir order to guide him towards his most preferred solution.

The rest of this chapter is organized as follows. Next section briefly describes the Reference Point based approach. In Sect. 13.3, the method to determine the synthetic social responsibility indicators is briefly described. Next, the portfolio selection model is presented and solved. Finally, in section "Conclusions" some conclusions and final remarks are given.[1]

13.2 The Reference Point Based Approach

In general, a Multiple Criteria Decision Making (MCDM) problem consists of analyzing (ranking, classifying, choosing) a series of possible alternatives, taking into account different criteria simultaneously. In our case, the set of alternatives is the set of mutual funds, while the criteria are the different SRI indicators. The idea is to give an overall measure of the social responsibility of each fund, by means of taking into account the values of all the indicators. Many different MCDM techniques have been developed so far (see, for example, Steuer (1986a) or Miettinen (1999), for overviews). In Chap. 1 we have briefly described the use of these techniques applied to the portfolio selection problem and in the second and third parts of this book, different applications of Goal Programming and Compromise Programming (the most used MCDM techniques) have been proposed.

[1]This chapter is closely related to and heavily based on Cabello et al. (2014) published in the European Journal of Operational Research

In this chapter we will focus on a different MCDM technique, the Reference Point Method. When the decision makers can give desirable values for each criterion, then it is natural to measure the goodness of each alternative in terms of its closeness to these desired levels. This is precisely the basic idea underlying the Reference Point approach, where the reference point is formed by these desirable values (called reference levels). Originally proposed in Wierzbicki (1980), this approach consists of considering a so-called achievement scalarizing function, which somehow gives an idea of how far is the alternative from satisfying the reference values. In a traditional multiobjective problem, where I objective functions f_i, $i = 1, \ldots, I$, have to be simultaneously optimized (let us say maximized), the simplest achievement scalarizing function takes the following form:

$$s(\mathbf{f}(\mathbf{x}), \mathbf{q}, \boldsymbol{\mu}) = \min_{i=1,\ldots,I} \{\mu_i (f_i(\mathbf{x}) - q_i)\}, \tag{13.1}$$

where $\mathbf{f}$ is the vector of objective functions (criteria), $\mathbf{x}$ is the vector of decision variables (alternatives), $\mathbf{q} = (q_1, \ldots, q_I)$ is the vector formed by the reference values, and $\boldsymbol{\mu}$ is a vector of weights, whose role can range from purely normalizing (scaling) factors to fully preferential parameters (Ruiz et al. (2009)). Under this formulation, the best alternative is the one that maximizes the achievement scalarizing function (13.1).

The original reference point scheme can be generalized if a double reference point (reservation-aspiration) is used. Namely, the decision maker is asked to give, for each criterion, a reservation level (i.e. a level under which the values of the function are not regarded as acceptable), and an aspiration level, with the same meaning as before (that is, desirable values for the criteria). Wierzbicki et al. (2000) proposed this scheme as a means of carrying out objective rankings of alternatives. Namely, if we denote by q_i^r and q_i^a the reservation and aspiration (respectively) values for criterion i, then, the following individual achievement scalarizing function can be used:

$$s_i(f_i(\mathbf{x}), q_i^a, q_i^r) = \begin{cases} \beta \frac{f_i(\mathbf{x}) - q_i^r}{q_i^r - q_i^{lo}}, & \text{if } q_i^{lo} \le f_i(\mathbf{x}) \le q_i^r, \\ \frac{f_i(\mathbf{x}) - q_i^r}{q_i^a - q_i^r}, & \text{if } q_i^r \le f_i(\mathbf{x}) \le q_i^a, \\ 1 + \alpha \frac{f_i(\mathbf{x}) - q_i^a}{q_i^{up} - q_i^a}, & \text{if } q_i^a \le f_i(\mathbf{x}) \le q_i^{up}, \end{cases} \tag{13.2}$$

where $\alpha > 0$ is a parameter that rewards the values of the function that improve the aspiration level, $\beta > 0$ is a penalizing factor for values under the reservation level, and q_i^{up} and q_i^{lo} are, respectively, upper and lower bounds for f_i over the feasible set of alternatives. This individual achievement function measures the behavior of the alternative with respect to criterion i (the higher the value of s_i, the better the performance is). Later on, these individual achievement functions can be aggregated in order to obtain an overall measure of each alternative. Wierzbicki et al. (2000) proposed to use the following achievement function:

$$s(\mathbf{f}(\mathbf{x}), \mathbf{q}^a, \mathbf{q}^r) = \min_{i=1,\ldots,I} \{s_i(f_i(\mathbf{x}), q_i^a, q_i^r)\} + \rho \sum_{i=1}^{I} s_i(f_i(\mathbf{x}), q_i^a, q_i^r), \qquad (13.3)$$

where ρ is a small positive number.

As mentioned before, the strong sustainability paradigm does not allow compensations among the different indicators. On the other hand, the weak paradigm does allow this kind of compensation. In this sense, the first term of the achievement function (13.3) can be regarded as an aggregation that follows the strong paradigm, while the second term can be considered to follow the weak paradigm. These facts have led us to adapt this double reference point scheme to our problem, as described next (see Cabello et al. (2014)). This scheme is based on the one described in Ruiz et al. (2010) for the determination of synthetic sustainability indicators.

Let us denote by N the number of indicators and by M the number of funds considered in the study, and let δ_i^j be the value of indicator i for fund j ($i = 1, \ldots, N$, $j = 1, \ldots, M$). In this study, all the indicators are of type "more is better" (which corresponds to the maximization scheme). As described later, the double reference points (reservation-aspiration) for each indicator have been chosen according to the DM's opinions about what is neutral and good (respectively) for each criterion.

Then, for each indicator i ($i = 1, \ldots, N$), and taking into account the reference points given by the decision maker, q_i^a and q_i^r, the following individual achievement function is considered:

$$s_i(\delta_i^j, q_i^a, q_i^r) = \begin{cases} \frac{\delta_i^j - q_i^r}{q_i^r - q_i^{\min}}, & \text{if } q_i^{\min} \le \delta_i^j \le q_i^r, \\ \frac{\delta_i^j - q_i^r}{q_i^a - q_i^r}, & \text{if } q_i^r \le \delta_i^j \le q_i^a, \\ 1 + \frac{\delta_i^j - q_i^a}{q_i^{\max} - q_i^a}, & \text{if } q_i^a \le \delta_i^j \le q_i^{\max}, \end{cases} \qquad (13.4)$$

where $q_i^{\min}$ and $q_i^{\max}$ are, respectively, the minimum and maximum value that the indicator can take. Therefore, we have adapted expression (13.2) by considering $\alpha = \beta = 1$. This way, as seen in Fig. 13.1, s_i takes values between -1 and 0 if δ_i^j is under the reservation value, values between 0 and 1 if δ_i^j is between the reservation and aspiration values, and values between 1 and 2 if δ_i^j is over the aspiration value. Note that different values of parameters α and β can be used in order to control the slopes of the first and last linear pieces of Fig. 13.1, allowing the DM to penalize more or less values under the reservation level, or to reward more or less values over the aspiration level. They can also be used in order to guarantee properties like concavity (traditionally assumed for utility functions in portfolio selection) of the achievement function. Nevertheless, in portfolio selection, concavity is usually assumed for utility functions regarding expected return, as

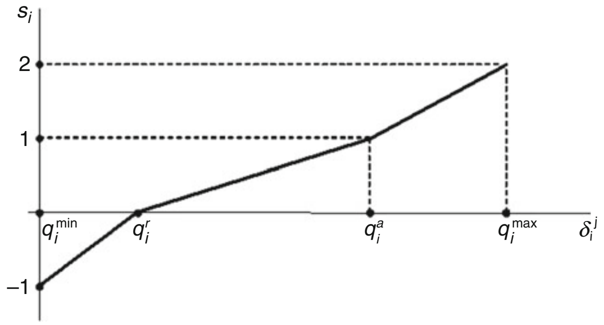

Fig. 13.1 Graphical representation of an individual achievement function s_i

greater return expectations are usually linked to greater risk assumptions. In our case, the return indicator, as will be seen later, is already a risk adjusted one, but still, the achievement function for this indicator, with $\alpha = \beta = 1$ is concave.

The weight factors used in the reference point schemes have traditionally had a normalization (scaling) aim. But it is also possible to use preferential weights in such schemes (Luque et al. (2009); Ruiz et al. (2009). Let ω_i denote the weight given to indicator i, and let us assume that the weights have been normalized so that $\sum_{i=1}^{N} \omega_i = 1$. Then, the weak synthetic indicator of each fund j is built using the classical additive scheme:

$$I_w^j = \sum_{i=1}^{N} \omega_i s_i(\delta_i^j, q_i^a, q_i^r). \tag{13.5}$$

This weak scheme allows full compensation among indicators. That is, a poor performance in one indicator can be compensated by a good performance in another one. Let us now describe how to build the strong synthetic indicator, which does not allow any compensation among the different indicators. The use of the direct minimization scheme (first term of achievement function (13.3)) can produce certain undesired effects:

- It would be desirable that, if a given alternative had the worst possible achievement value (in our case, -1) for the indicator with the greatest weight (the most important one), then the value of the strong indicator was the worst possible one (-1). This is not guaranteed by the direct minimization scheme.
- If all the achievement values of a given alternative are greater than 1 (that is, the alternative performs over the reference levels for all the indicators), then the strong indicator should also be greater than 1. Again, the direct minimization does not guarantee this.
- When the direct minimization scheme is used, the effect of the weights is opposite for negative and positive achievement values. For negative achievement values, a greater weight produces a worse value of the strong indicator, and for

positive achievement values a greater weight produces a better value of the strong indicator.

In order to avoid these effects, we have designed a modified procedure to develop the strong indicator. The idea underlying this procedure is to consider only indicators in the worst set (if there are negative achievement values, only these values are considered; if there are not negative values, but there are values under 1, only these values are considered; if all the values are over 1, all of them are considered). Then a translation is made to put the values considered in the [−1,0] interval, so that the effect of the weights is the desired one, and after calculating the minimum value, it is again translated to the original interval. Besides, weights are modified so that the greatest weight is 1. To build this indicator, the following procedure must be followed:

- Build the modified weights $\bar{\omega}_i$:

$$\bar{\omega}_i = \frac{\omega_i}{\max_{k=1,\dots,N} \omega_k}, \quad i = 1, \dots, N$$

- Let us denote $I = \{1, \dots, N\}$. For each fund j, let us denote $s_i^j = s_i(\delta_i^j, q_i^a, q_i^r)$, and let us define the following sets of indexes:

$$I_j^0 = \{i \in I / s_i^j < 0\},$$
$$I_j^1 = \{i \in I / s_i^j < 1\},$$

$$\bar{I}_j = \begin{cases} I_j^0, & \text{if } I_j^0 \neq \emptyset; \\ I_j^1, & \text{if } I_j^0 = \emptyset, \text{and } I_j^1 \neq \emptyset; \\ I, & \text{otherwise.} \end{cases}$$

- We define the correction constant

$$k_j = \begin{cases} 0, & \text{if } I_j^0 \neq \emptyset; \\ 1, & \text{if } I_j^0 = \emptyset, \text{and } I_j^1 \neq \emptyset; \\ 2, & \text{otherwise.} \end{cases}$$

  and the corresponding corrected values of the achievement functions for fund j:

$$\bar{s}_i^j = s_i^j - k_j, \quad i \in \bar{I}_j.$$

- We define the strong synthetic indicator of fund j:

$$I_s^j = k_j + \min_{i \in \bar{I}_j} \bar{\omega}_i \bar{s}_i^j. \tag{13.6}$$

Finally, given that the weak and strong indicators are extreme cases, allowing full compensation and no compensation (respectively), partially compensatory synthetic indicators can be built as follows:

$$I_{\lambda}^{j} = \lambda I_{w}^{j} + (1-\lambda) I_{s}^{j}, \qquad (13.7)$$

where $\lambda \in [0, 1]$ is the compensation coefficient: the larger the value of λ, the more compensation is allowed. For $\lambda = 0$, we obtain the strong indicator, and for $\lambda = 1$, we obtain the weak indicator.

13.3 Synthetic Indicators of Stocks' Social Responsibility

The evaluation model proposed in this chapter is based on the Reference Point Method described in previous sections, which allows us to obtain weak, strong and mixed non-financial synthetic indicators for each stock and each non-financial criterion. In order to obtain the synthetic indicators we have considered the following steps:

STEP 1. Identification of the relevant environment, social and governance investment indicators.

In Chap. 4 we have described how several independent agencies try to supply transparent and credible information about the social, labor and environmental performance of companies throughout the world. Some examples are KLD, Vigeo, Innovest, Oekom Research, Corporate Monitoring, EthicScan Canada or EIRIS. In this chapter we will rely on Vigeo's list of social, environmental, governance and ethical criteria as a departure point for discussing and obtaining an agreed list of non-financial criteria for socially responsible ranking of mutual funds. As we have seen in Chap. 4, Equitics® is a model developed by Vigeo based on internationally recognised standards with which they assess the degree to which companies under review take the social responsibility objectives of their analysis ratings model into account in the definition and deployment of their strategy. They offer access to ratings in the six domains: Human Rights; Human Resources; Environment; Business Behaviour; Corporate Governance and Community Involvement. They consider 28 non-financial criteria and provide more than 300 indicators for each company.

Therefore, following Vigeo, we have considered six indicators of social responsibility which correspond to the previously described main corporate social responsibility dimensions used by Vigeo to rate companies. Each company in the database is rated with respect to these dimensions and an individual score is assigned which takes values in the interval [0, 100].

STEP 2. Definition of the reference levels associated with each indicator: "good" (aspiration) and "neutral" (reservation) performance levels.

Vigeo provides information about the average score of each economic sector with respect to each dimension. Thus, each company can be rated with respect to the average performance of the companies belonging to its economic sector. In this work we have used this information to fix the aspiration and reservation levels for each non-financial dimensions. Namely, following Wierzbicki et al. (2000), if s^{av} is the average score of a given economic sector for a given dimension, then the following statistical reference levels are considered:

$$s^r = \frac{s^{av}}{2}, \quad s^a = s^{av} + \frac{100 - s^{av}}{2}, \tag{13.8}$$

where s^r and s^a are the reservation and aspiration values, respectively. Therefore, s^r is half way between the minimum (0) and the average values, and s^a is half way between the average and the maximum (100) values. These statistical weights produce a final score that has to be interpreted as the relative position of each firm with respect to the firms of the same sector. Of course, other type of aspiration levels (e.g., given by experts) can also be used.

STEP 3. Weighting scheme.

Different approaches can be followed in order to establish particular and subjective weights for the criteria (see for example Perez-Gladish and M'Zali 2010; Cabello et al. (2014). In this work equal weights have been used for all the dimensions, but we can also let experts or the investor to give these weights.

STEP 4. Construction of the synthetic indicators.

First, and following the procedure described in previous section, an individual achievement function is built for each dimension. This function takes values between -1 and 2. Namely, if a firm performs under the reservation level for a given dimension, the corresponding achievement function takes a value between -1 and 0. If the firm performs between the reservation and the aspiration values, then the achievement function is between 0 and 1. Finally, for scores over the aspiration level, the achievement function is between 1 and 2. Next, the synthetic indicators are built. The weak indicator (I^w) is based on the weighted sum scheme, and thus, it allows full compensation among the dimensions. The strong indicator (I^s) is based on a max-min scheme, and thus, it does not allow compensation. Both synthetic indicators take values between -1 and 2 and therefore, they can be interpreted as the overall performance of the firm with respect to global reservation and aspiration levels. Finally, the mixed indicator, for a given compensation degree λ $(0 \leq \lambda \leq 1)$ is built $I^\lambda = \lambda I^w + (1 - \lambda) I^s$.

13.4 Portfolio Selection Model

In this chapter we are interested in presenting a single period portfolio selection model for selecting stocks from the Spanish Stock Market, taking into account not only the classical financial criteria but also, environmental, social and governance criteria. This type of investment is still very marginal in Spain due to the general risk profile of its investors (see Fig. 13.2).

Our initial database consisted of the 213 stocks domiciled in Spain on January 22, 2014 and for which financial data were available from Morningstar Ltd. From these stocks we finally selected 32 which were the Spanish domiciled stocks rated by the social rating agency Vigeo in 2012 and for which non-financial data are available in their database, Equitics.

Historical financial return data have been considered from October 14, 2007 to October 11, 2014, expressed in percentage terms and calculated by Morningstar Ltd as follows:

$$r_{jt} = \frac{P_{jt+1} - P_{jt}}{P_{jt}} \times 100, \tag{13.9}$$

where r_{jt} is the return of stock j at a moment t; P_{jt+1} is the closing price of stock j at a moment $t + 1$ and P_{jt} is the closing price of stock j at a moment t. In order to calculate expected return and the covariance matrix weekly returns have been considered.

Non-financial data from Vigeo's database Equitics consisted of individual scores for the six socially responsible dimensions described in Sect. 13.3 available at the end of 2012. Taking into account the reference levels, the weak, strong and mixed corporate social responsibility synthetic indicators were obtained for each company (see Table 13.1).

In order to have a deeper knowledge of the 32 selected stocks, we show several tables (for several sectors) where the market capitalization (in million euros) and the Price/Earnings ratio (P/E) are displayed. These numbers give us an idea of how big is the firm and how cheap is it, in terms of earnings.

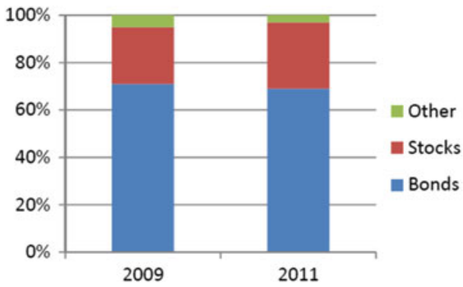

Fig. 13.2 Distribution of socially responsible assets in Spain (Source: Spainsif (2012))

Table 13.1 Social responsibility synthetic indicators, expected return and Sharpe ratio of the stocks

N	Stock	Sector	Social resp. indicators			Exp. return	Sharpe ratio
			I^w	I^s	$I^{0.5}$	%	
1	Abertis	Transport & logistics	0.53	0.28	0.40	2.80	0.70
2	Acciona	Heavy construction	0.36	0.20	0.28	−12.27	−2.17
3	Acerinox	Mining & metals	0.15	0.01	0.08	−5.37	−1.29
4	ACS	Heavy construction	0.19	0.06	0.13	3.90	0.88
5	Atresmedia	Broadcasting & advertising	−0.31	−1.00	−0.65	18.28	2.78
6	BBVA	Banks	0.66	0.51	0.58	2.97	0.50
7	Sabadell	Banks	0.60	0.29	0.44	−7.65	−1.34
8	Santander	Banks	0.38	0.16	0.27	4.99	0.84
9	Bankinter	Banks	0.45	0.15	0.30	4.66	0.71
10	BME	Financial services – General	0.44	−0.07	0.18	6.95	1.59
11	CaixaBank	Financial services – General	0.57	0.37	0.47	7.53	1.58
12	CF Alba	Financial services – General	−0.51	−1.00	−0.75	6.13	1.43
13	Ebro Foods	Food	0.17	−0.32	−0.07	9.41	3.26
14	Enagas	Electric & gas utilities	0.61	0.26	0.44	8.82	2.35
15	Faes Farma	Pharmaceuticals & biotech	−0.35	−0.90	−0.63	−11.97	−1.89
16	Ferrovial	Transport & logistics	0.43	0.24	0.33	16.33	3.15
17	FCC	Heavy construction	0.30	0.13	0.22	−6.25	−1.05
18	Gamesa	Electric comp. & equip.	0.39	0.10	0.24	−6.34	−0.91
19	Gas natural	Electric & gas utilities	0.52	0.36	0.44	−1.41	−0.29
20	Grifols	Pharm. & biotechnology	0.13	0.01	0.07	19.51	4.60
21	Iberdrola	Electric & gas utilities	0.61	0.44	0.52	−2.30	−0.50
22	Indra	Software & IT services	0.77	0.66	0.72	2.24	0.55
23	Inditex	Specialised retail	0.46	0.16	0.31	22.86	5.60
24	Mapfre	Insurance	0.24	0.03	0.14	13.25	2.53
25	Mediaset	Broadcasting & advertising	0.27	0.13	0.20	3.20	0.51
26	NH Hoteles	Hotel, Leisure G. & services	−0.15	−0.85	−0.50	−2.77	−0.37
27	Prisa	Publishing	−0.17	−1.00	−0.58	−26.53	−2.55
28	REE	Electric & gas utilities	0.61	0.37	0.49	13.02	3.39
29	Repsol	Energy	0.59	0.39	0.49	6.58	1.43
30	Sacyr	Heavy construction	0.26	0.05	0.15	−15.38	−1.97
31	Telefónica	Telecommunications	0.63	0.28	0.45	0.00	0.00
32	Zardoya	Mech. comp. & equipment	0.10	−0.27	−0.08	−1.44	−0.38

Source: Morningstar

13.4.1 Banks and Financial Services

Banks and Financial Services is the sector with more stocks. BBVA and Santander are the greatest banks, together with CaixaBank. Besides, we can find the medium

Table 13.2 Banks & financial services

Stock	Capitalization	P/E
BBVA	52,131	15.35
Sabadell	9,508	41.11
Santander	75,794	16.71
Bankinter	5,296	21.90
BME	2,500	18.46
CaixaBank	23,276	43.75
CF Alba	2,525	N/A

Source: Morningstar

Table 13.3 Broadcasting, advertising & publishing

Stock	Capitalization	P/E
Atresmedia	2,876	85.76
Mediaset	3,661	71.87
Prisa	413	N/A

Source: Morningstar

sized banks as Bankinter and Sabadell, and firms of financial services such as BME and CF Alba (Table 13.2).

13.4.2 Broadcasting, Advertising and Publishing

The Broadcasting, Advertising and Publishing sector is formed by the two most important media companies, which are now recovering from the great recession. This makes them to be expensive in terms of P/E, due to the expectative of the investor. Prisa is the editor of the most important newspaper of Spain and it is presently undergoing a deep restructuring (Table 13.3).

13.4.3 Electric, Gas Utility and Energy

The energy sector is the most compact one. All the stocks form a group of regulated economy companies. The P/E of the sector is quite the same, except Gamesa that is specialized in renewable energy (Table 13.4).

13.4.4 Heavy Construction and Logistics

This sector is in a full restructuring period after the great recession. The boom of construction in Spain made them to expand abroad and to diversify their business. All of them had losses during the past years (Table 13.5).

Table 13.4 Electric, gas & energy

Stock	Capitalization	P/E
Enagas	5,222	12.95
Gas Natural	19,288	13.35
Iberdrola	30,726	12.23
REE	7,774	15.71
Gamesa	2,182	N/A
Repsol	24,006	13.62

Source: Morningstar

Table 13.5 Heavy construction & logistics

Stock	Capitalization	P/E
Acciona	3,289	17.39
ACS	8,391	N/A
FCC	2,009	N/A
Sacyr	2,065	N/A
Abertis	14,373	12.97
Ferrovial	11,457	16.14

Source: Morningstar

Table 13.6 Rest of stocks

Stock	Sector	Capitalization	P/E
NH Hoteles	Hotel, Leisure goods & services	1,463	N/A
Mapfre	Insurance	9,103	11.49
Indra	Software & IT services	2,276	17.16
Inditex	Specialised retail	65,886	27.91
Telefónica	Telecommunications	51,427	12.94
Ebro Foods	Food	2,507	15.58
Zardoya	Mechanical components & equipment	5,236	26.38
Acerinox	Mining & metals	2,782	N/A

Source: Morningstar

13.4.5 Rest of Stocks

The rest of stocks belong to different sectors. Among them we can find the two biggest companies of the IBEX35. Telefonica and Inditex have most of their business outside the country. This reason has helped them to overcome the crisis (Table 13.6).

In our study, three objectives have been considered: maximization of the expected return, minimization of risk given by the variance and a non-financial criterion, maximization of the portfolio's social responsibility.

There are two sets of decision variables in our model. On the one hand, y_j $(j = 1, \ldots, 32)$ are binary variables that take the value 1 if the corresponding stock is in the selected portfolio, and 0 otherwise. On the other hand, decision variables, x_j, indicate the amount of the investor's budget to be invested in each stock j. If stock j belongs to sector h, we will write $j \in S^h$. We will denote the number of sectors by N_s. The auxiliary binary variables have been introduced in the model in order to model the constraints that ensure that the investment bounds constraints are only active for those funds already selected to be included in the portfolio (see, e.g. Calvo et al. 2012, 2014).

The portfolio's expected return is defined as:

$$ER(\mathbf{x}) = \sum_{j=1}^{32} ER_j x_j, \tag{13.10}$$

where ER_j is a random variable representing the expected return of stock j. The portfolio's weekly expected return will be approximated considering the historical mean as the forecast of the expected return on the stock for a given observation period T which in our case consists of 326 weeks:

$$ERW_j = \frac{1}{T}\sum_{t=1}^{T} r_{jt}, \quad j = 1, \ldots, 32 \tag{13.11}$$

and we have annualized it afterwards:

$$ER_j = (1 + ERW_j)^{52} - 1.$$

Here, r_{jt} is the realization of the random variable ER_j over the period t obtained using the historical data.

The portfolio's risk is defined as:

$$\sigma^2(\mathbf{x}) = \sum_{j=1}^{32}\sum_{r=1}^{32} \sigma_{jr} x_j x_r, \tag{13.12}$$

where σ_{jr} is the covariance between returns of stocks j and r. It will be approximated as follows:

$$\hat{\sigma}_{jr} = \frac{1}{T}\sum_{t=1}^{T}(r_{jt} - ERW_j)(r_{rt} - ERW_r), \quad j, r = 1, \ldots, 32. \tag{13.13}$$

The portfolio's social responsibility will be defined as:

$$SR(\mathbf{x}) = \sum_{j=1}^{32} I_j^{0.5} x_j, \tag{13.14}$$

where $I^{0.5}$ is the social responsibility mixed indicator for $\lambda = 0.5$ (see Eq. 13.7). Figure 13.3 shows the ranking of the 32 firms of the study with respect to the

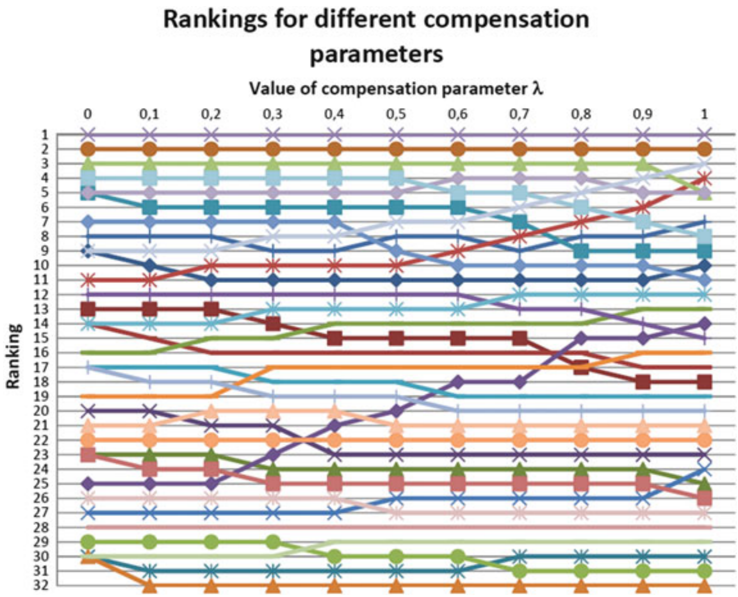

Fig. 13.3 Ranking of the 32 stocks, for the mixed indicator I^{λ}, for different values of λ

Table 13.7 Parameters in the model

Parameter	Value
Maximum investment	100
Minimum investment per stock (if invested)	5
Maximum investment per stock	20
Maximum investment per sector	40
Maximum number of stocks	10

mixed indicator I^{λ}, for different values of λ between 0 and 1. As can be seen, the middle compensation zone (between 0.4 and 0.6), is quite stable, not showing many changes of positions, and none of them too large. Therefore, we have chosen to use the middle value 0.5 for the mixed indicator. This value will be used as the social responsibility measure for each stock. The values of the weak, strong and mixed indicators for each stock can be seen in Table 13.1.

With regard to the constraints and, together with the budget and non-negativity classical constrains, minimum-maximum investment bounds on individual stocks have been included in the model together with other diversification constraints: sectorial constraints and cardinality constraints (maximum number of stocks in the portfolio). Bounds on assets selected to be included in the portfolio are also included (see Eqs. 13.18–13.23). Table 13.7 displays the parameters considered for a fictitious investor.

Therefore, the final model takes the following form:

$$\max \quad ER(\mathbf{x}) = \sum_{j=1}^{32} ER_j x_j \quad \rightarrow \quad \text{Expected return} \tag{13.15}$$

$$\min \quad \sigma^2(\mathbf{x}) = \sum_{j=1}^{32}\sum_{r=1}^{32} \sigma_{jr} x_j x_r \quad \rightarrow \quad \text{Risk (Variance)} \tag{13.16}$$

$$\max \quad SR(\mathbf{x}) = \sum_{j=1}^{32} I_j^{0.5} x_j \quad \rightarrow \quad \text{Social Responsibility} \tag{13.17}$$

$$\text{s.t.} \quad \sum_{j=1}^{32} x_j = 100 \quad \rightarrow \quad \text{Budget Constraint} \tag{13.18}$$

$$\sum_{j \in S^h} x_j \leq 40 \quad (h = 1, \ldots, N_s) \quad \rightarrow \quad \text{Sectorial Constraints} \tag{13.19}$$

$$\sum_{j=1}^{32} y_j \leq 10 \quad \rightarrow \quad \text{Cardinality Constraints} \tag{13.20}$$

$$5y_j \leq x_j \leq 20y_j \quad (j = 1, \ldots, 32) \quad \rightarrow \quad \text{Bounds on Stocks} \tag{13.21}$$

$$y_j \in \{0, 1\} \quad (j = 1, \ldots, 32) \quad \rightarrow \quad \text{Auxiliary Variables} \tag{13.22}$$

$$x_j \geq 0 \quad (j = 1, \ldots, 32) \quad \rightarrow \quad \text{Non-negativity Conditions} \tag{13.23}$$

First, each individual optimization problem was solved in order to obtain the corresponding ideal values. From the pay-off matrix, we also obtained the anti-ideal value of each objective. These values are displayed in Table 13.8.

The absolute value of the difference between the ideal and anti-ideal value of each objective will be used as a normalizing (scaling) factor in what follows, and they will be denoted by N^{er}, N^r and N^s, respectively. In order to solve the portfolio selection problem, an interactive environment has been implemented in GAMS. Namely, at each iteration, the decision maker has two options:

- Giving reference levels (levels which are considered as desirable by the decision maker) for each objective and, possibly, preferential weights measuring the desirability of achieving each level (see Wierzbicki (1980); Luque et al. (2009).

Table 13.8 Ideal and anti-ideal values of the objective functions

Criterion	Ideal	Anti-ideal
Return (%)	18.045	4.502
Risk (%)	252.300	382.092
Social resp.	0.561	0.039

Let q^{er}, q^{r} and q^{sr} be, respectively, the reference levels for the expected return, risk and social responsibility, and let ω^{er}, ω^{r} and ω^{sr} be the corresponding weights. Then, the following single optimization problem is solved to get a new efficient solution of the problem:

$$\begin{aligned}
\min \quad & d + \rho\left(\frac{\omega^{er}}{N^{er}}(ER(\mathbf{x}) - q^{er}) + \frac{\omega^{r}}{N^{r}}(\sigma^2(\mathbf{x}) - q^{r}) + \frac{\omega^{sr}}{N^{sr}}(SR(\mathbf{x}) - q^{sr})\right) \\
\text{s.t.} \quad & \frac{\omega^{er}}{N^{er}}(ER(\mathbf{x}) - q^{er}) \leq d \\
& \frac{\omega^{r}}{N^{r}}(\sigma^2(\mathbf{x}) - q^{r}) \leq d \\
& \frac{\omega^{sr}}{N^{sr}}(SR(\mathbf{x}) - q^{sr}) \leq d \\
& \text{Constraints (13.18)–(13.23)}
\end{aligned}$$

- A classification scheme, following Miettinen and Makela (1995), can be carried out. The decision maker can classify the objectives into (up to) five classes:
  - Objectives to be improved as much as possible,
  - Objetives to be improved up to a desired value q,
  - Objectives which are satisfactory at their present values,
  - Objectives that can be impaired down to some level ε,
  - Objectives that can be freely impaired.

  Once the classification is made and the values q and ε are given (if any), a reference point based problem is solved, where only the objectives to be improved are included in the objective function, and additional constraints are used for the new bounds set (see Miettinen and Makela (1995), for further details).

Two different investors' profiles have been simulated: a conventional investor and a socially responsible conscious investor. Each of them has been asked to solve the problem using the interactive scheme, until a final satisfactory portfolio is obtained.

The conventional investor carried out two iterations using the interactive reference point scheme, which can be seen in Table 13.9. In the first iteration, the decision maker set reference levels of 12 % for the return, and 300 % for the risk, while the social responsibility was set close to the anti-ideal value. This reference point

Table 13.9 Iterations of the conventional investor using the reference point scheme

	Reference point			Weight			Solution achieved		
It	Return (%)	Risk (%)	Resp.	Return	Risk	Resp.	Return (%)	Risk (%)	Resp.
1	12	300	0.04	2	2	1	14.803	270.111	0.256
2	16	270	0.04	2	2	1	15.463	275.977	0.174

Table 13.10 Portfolio obtained for the conventional investor

No.	Stock	Sector	% investment
5	Atresmedia	Broadcasting & advertising	8.154
13	Ebro Foods	food	20
14	Enagas	Electric & gas utilities	5
16	Ferrovial	Transport & logistics	8.38
20	Grifols	Pharmaceuticals & biotechnology	20
23	Inditex	Specialised retail	20
28	REE	Electric & gas utilities	18.466

Table 13.11 Iterations of the socially conscious investor using the reference point scheme

	Reference point			Weight			Solution achieved		
It	Return (%)	Risk (%)	Resp.	Return	Risk	Resp.	Return (%)	Risk (%)	Resp.
1	17	320	0.5	1	1	1	14.362	306.988	0.398
2	17	320	0.5	4	1	5	14.055	306.906	0.409
3	18	350	0.56	4	1	5	13.605	307.412	0.425

proved to be achievable, and better values were obtained for the three objectives. Then, in the second iteration, the decision maker set better values for the return and the profit. In this case, the reference point was unachievable, and the values obtained were 15.5 % return, 276 % risk and 0.17 social responsibility.

At this point, the decision maker wished to carry out another iteration using the classification scheme, in order to improve the return objective as much as possible, while the risk is kept under 285 %, and the social responsibility is kept over 0.1. In both cases, social responsibility was assigned half the weight of the other two objectives. In this final solution, the return achieved was 16.059 %, the risk was 285 % and the social responsibility equaled 0.148. These iterations proved that, with the stocks selected, there is no need to allow very low values of the social responsibility in order to achieve a good value for the expected return. The final composition of the portfolio can be seen in Table 13.10.

On the other hand, the socially conscious investor carried out three iterations using the interactive reference point scheme, which can be seen in Table 13.11. In the first iteration, he decided to give optimistic levels for the return and the social responsibility, and a high level (320 %) for the risk. In the solution obtained, the risk was improved, and the other two objectives were worsened. That is why he decided to carry out a new iteration, increasing significantly the weights of these two objectives, but the solution was only slightly better. In the third iteration, he set even more optimistic values for the return and the social responsibility. The final value of the social responsibility was high (0.425), and the expected return was worse that the others. Again, the risk did not impair too much. Therefore, the conclusion was reached that, at these levels, the real tradeoff was between social responsibility and expected return.

Table 13.12 Portfolio obtained for the socially conscious investor

No.	Stock	Sector	% investment
6	BBVA	Banks	19.966
16	Ferrovial	Transport & logistics	15.034
22	Indra	Software & IT services	20
23	Inditex	Specialised retail	20
28	REE	Electric & gas utilities	20
29	Repsol	Energy	5

Finally, the decision maker decided to carry out an iteration using the classification scheme. He wished the social responsibility to increase as much as possible, while the expected return was allowed to take values over 11 %. The risk was allowed to impair freely. In the final result obtained, the expected return was 11 %, while the social responsibility took a value of 0.494. The risk went up to 356.824 %. The final composition of the portfolio can be seen in Table 13.12.

We can observe that there are stocks that belong to both portfolios. As seen in Table 13.1, this is due to the fact that they take good values for the SCR criteria, as well as for profitability and risk. These two criteria are summarized in Table 13.1 through the use of the Sharpe ratio. These stocks are Ferrovial, Inditex and REE.

The remaining stocks of each portfolio are selected in order to satisfy the decision makers' preferences in each case, in order to make each portfolio approach the corresponding reference as much as possible. In the conventional investor's portfolio, Ebro foods, Atresmedia and Enagas show an outstanding behaviour with respect to the Sharpe Ratio, but a very reduced SCR value. Conversely BBVA and Indra form the socially conscious investor's portfolio with highly valued SCR and low Sharpe Ratio.

Conclusions

A portfolio selection model has been presented for different types of investors' profiles, including a non-financial objective: maximizing the portfolio social responsibility degree.

The proposed model is able to include a more or less non-compensatory nature of the criteria, i.e., through the use of the mixed synthetic indicator for different values of the compensation parameter. This indicator is a compromise between the weak indicator, which allows full compensation, and the strong indicator, which does not allow any compensation at all.

The interactive environment developed relies on the Reference Point method and on the classification schemes. It allows the investor, through an interactive process, to fix different reference levels for the criteria and to explore the obtained portfolios adapting them to his personal preferences. The investor also has the option to carry out a classification of the objectives,

(continued)

to decide which ones does he wish to be improved, and which others are allowed to impair. This environment has proved to be flexible enough to let the decision maker express his wishes freely, and to guide him towards his most preferred solution.

There is an important debate around the selection of the adequate risk measures in portfolio selection. This is a multicriteria decision making problem itself. Therefore, in future works we propose to build a more comprehensive portfolio selection framework including not single indicators for return and risk but synthetic indicators, in order to enrich the information included in the model. Individual investors have also preferences about transaction costs, fees, liquidity and dividends and therefore it seems necessary to include additional constraints in the portfolio selection model.

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Chapter 14
Soft Computing Techniques for Portfolio Selection: Combining SRI with Mean-Variance Goals

Clara Calvo, Carlos Ivorra, and Vicente Liern

Abstract A fuzzy portfolio selection model is presented incorporating a socially responsible goal without discarding a priori financially good portfolios or weakening a priori the financial goals. Hence, the optimal portfolios it provides could be either efficient from the strictly financial point of view or non-efficient if leaving the efficient frontier substantially improves the degree of social responsibility. The model can be used to direct heuristic procedures in order to select a reduced number of various alternatives from which the investor can directly make a final decision.

14.1 Introduction

This chapter is devoted to illustrating the applications of Fuzzy Set Theory to portfolio selection under social responsibility criteria. Roughly speaking, Fuzzy Set Theory allows to formalize imprecise aspects of the real world that by their nature do not fit the framework provided by probability theory. Specifically, in the context of investment, we will be concerned with incorporating two kinds of fuzziness into a multicriteria portfolio selection model. Namely, that related to the subjective investor's preferences and that appearing when trying to evaluate the degree of social responsibility of a firm, a mutual fund or a portfolio.

Notice that in both cases probability theory could not be applied in a natural way in the sense that, for instance, we cannot speak of the probability that a given investor likes a portfolio to a larger or lesser extent according to the characteristics of the funds it comprises. We can show the portfolio to the investor and the question is not whether he or she is going to say 'I like it' or 'I do not like it', but the real problem is that we can expect that he or she will say 'It could be acceptable', or 'I like it quite a lot' and so on. Similarly, assuming we have enough reliable information about the investment policy of a firm, we cannot formulate

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probabilities on the social responsibility of the firm, but the problem is how to aggregate all the information available, and Fuzzy Set Theory provides an adequate framework.

14.2 Elements of Fuzzy Set Theory

As is well known, the formalization of all modern mathematics relies on the primitive concept of set. In classical Set Theory, given a set A, we have exactly two possibilities for each object x, namely, x can either belong or not belong to A. The main idea of Fuzzy Set Theory (Zadeh 1965) is to provide a formal framework in which we can speak of elements that definitely belong to a given fuzzy set $\tilde{A}$, elements that definitely do not belong to $\tilde{A}$, but also of elements that just belong to $\tilde{A}$ to some extent, or in other words, that partially belong to $\tilde{A}$. This is formalized by establishing that a fuzzy set $\tilde{A}$ is not really a set, but a function assigning to each possible member of $\tilde{A}$ a degree of membership:

Definition 14.1 Given a reference set X, a *fuzzy set* $\tilde{A}$ in X is defined as:

$$\tilde{A} = \{(x, \mu_{\tilde{A}}(x)), \quad x \in X\} \tag{14.1}$$

where $\mu_{\tilde{A}} : X \longrightarrow [0, 1]$ is called the membership function of $\tilde{A}$. For each $x \in X$, the real number $\mu_{\tilde{A}}(x)$ is called the *degree of membership* of x to $\tilde{A}$.

In these terms, a degree $\mu_{\tilde{A}}(x) = 1$ means that x belongs to $\tilde{A}$, a degree $\mu_{\tilde{A}}(x) = 0$ means that x does not belong to $\tilde{A}$, whereas an intermediate degree $0 < \mu_{\tilde{A}}(x) < 1$ corresponds to a partial member of $\tilde{A}$.

Example 14.1 Assume that an investor would like to obtain a return $r = 0.20$ in an investment but would be willing to reduce it until at most $r = 0.10$ if this provides some other benefits in exchange. Then we can define the set $\tilde{A}$ of acceptable returns for this investor as that given by the following membership function (see Fig. 14.1):

$$\mu_{\tilde{A}}(x) = \begin{cases} 1 & \text{if } x \geq 0.20, \\ \dfrac{x - 0.10}{0.10} & \text{if } 0.10 < x < 0.20, \\ 0 & \text{if } x \leq 0.10. \end{cases}$$

Despite the large number of situations that can be described by means of fuzzy sets, one way to simplify the construction of a membership function (particularly if the valuation is obtained from the opinion of some experts) is to extend the concept of fuzzy set, admitting that the membership function is a tolerance interval, that is, a multi-valuated membership function. This generalization of fuzzy sets, introduced by Sambuc (1975), can be expressed (Burillo and Bustince 1996) as:

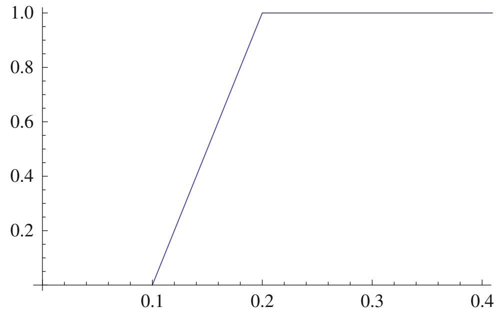

Fig. 14.1 Membership function for the set of acceptable returns of Example 14.1

Definition 14.2 Given a $\tilde{A}^{\Phi} : X \to D\,[0,1]$, given by $\mu_{\tilde{A}}(x) = \left[a_x^L, a_x^U\right] \in D\,[0,1]$, defines the degree of membership of an element x to A. The expression $D\,[0,1]$ denotes the set of all the closed subintervals on the interval $[0,1]$. In general, when the reference set is finite, $X = \{c_1, c_2, \ldots, c_P\}$, the interval-valued fuzzy set has the expression

$$\tilde{A} = \left\{ \left(c_r,\ \mu_{\tilde{A}}(c_r)\right)\ ,\ 1 \le r \le P \right\} = \left\{ \left(c_j,\ \left[a_r^L,\ a_r^U\right]\right)\ ,\ 1 \le r \le P \right\}. \tag{14.2}$$

Now let us recall how fuzzy set theory can be used in order to introduce fuzziness into an optimization problem. The seminal paper on the topic is Bellman and Zadeh (1970), but we follow Zimmermann (1997) (see also Delgado et al. 1994).

Definition 14.3 A *fuzzy optimization* problem is determined by a *fuzzy constraint* set $\tilde{C}$ and a *fuzzy goal set* $\tilde{G}$ in the same reference set X. The *decision set* of a fuzzy optimization problem is defined as the fuzzy intersection $\tilde{D} = \tilde{C} \cap \tilde{G}$ of the constraint and the goal set, i.e. the fuzzy set whose membership function is given by

$$\mu_{\tilde{D}}(x) = \min\{\mu_{\tilde{C}}(x), \mu_{\tilde{G}}(x)\}.$$

The optimal solutions of the problem are those maximizing the membership degree of the decision set. We will call this degree the *global satisfaction level* of a given solution (see Fig. 14.2).

The set X contains all the possible solutions of the problem (feasible or infeasible). However, now we do not distinguish between feasible and infeasible solutions anymore, but instead the fuzzy constraint set allows us to speak about partially feasible solutions that the decision-maker could consider more or less acceptable. On the other hand, the goal set measures how satisfactory a given solution is considered to be by the decision-maker. Hence, the set $\tilde{G}$ classifies the possible solutions into absolutely satisfactory solutions and absolutely inadmissible solutions, but also into partially satisfactory solutions that the decision-maker could approve of in some cases.

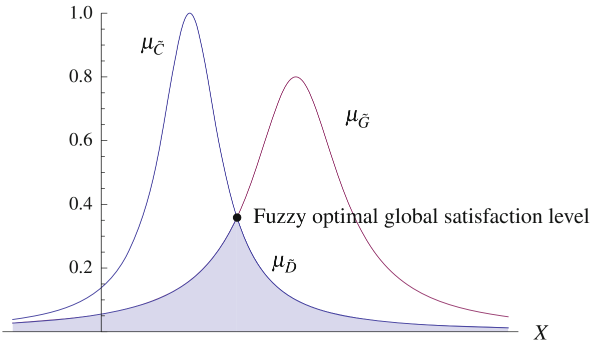

Fig. 14.2 Membership functions determining a fuzzy optimization problem. The fuzzy optimal solution is that solution in X maximizing the global degree of satisfaction.

14.3 Fuzzy Measurement of Social Responsibility

Let us consider n equity mutual funds $\{F_1, F_2, \ldots, F_n\}$ which invest principally in stocks (also known as shares or equities) which are portions of ownership of a corporation or firm. Let us consider a set $\{f_k\}_{k=1}^{q}$ of q firms in which the funds can invest at a certain moment of time. As equity mutual funds invest almost 100 % in stocks we will evaluate the degree of social responsibility of the funds by evaluating the degree of social responsibility of the firms they invest in. In order to do so, we will take into account m social screens $\{s_1, s_2, \ldots, s_m\}$, which as we have seen in Chap. 4, are the usual screens applied by the main rating agencies.

Due to the imprecise description of the screens, made in linguistic terms, it is difficult for the expert to evaluate each firm with respect to each screen using a single crisp (precise) numerical value. Thus, we will evaluate firms by means of interval-valued fuzzy sets. Our approach includes five steps:

STEP 1: Valuation

Similarly to the procedure followed by Gil-Aluja (1998) or Canós and Liern (2004) for the problem of personnel selection, in this chapter we will assume that the expert will evaluate the degree of social responsibility of each firm k with respect to each screen j by assigning it an interval inside $[0, 1]$:

$$\tilde{s}_{kj} = \left\{(s_{kj}, [b_{kj}^L, b_{kj}^U]), \quad 1 \leq k \leq q,\ 1 \leq j \leq m\right\} \tag{14.3}$$

where $[b_{kj}^L, b_{kj}^U] \subseteq [0, 1]$.
Thus, we obtain for each firm a discrete fuzzy set in which the interval $[b_{kj}^L, b_{kj}^U]$ represents the membership function of firm k with respect to the social screen j, considered as a tolerance interval.

STEP 2: Aggregation

Once these intervals are obtained for each screen we can aggregate them in order to obtain a unique interval representing the social responsibility degree of each firm k:

$$[b_k^L, b_k^U] = \sum_{j=1}^{m} [b_{kj}^L, b_{kj}^U], \quad 1 \leq k \leq q. \tag{14.4}$$

Then, taking into account the percentage invested in each firm by each mutual fund, we can obtain a fuzzy number $\tilde{s}_i$ representing the degree of social responsibility of each mutual fund:

$$[b_i^L, b_i^U] = \sum_{k=1}^{q} \alpha_k^i [b_k^L, b_k^U], \quad 1 \leq i \leq n, \tag{14.5}$$

Where $\alpha_k^i \in [0, 1]$ represents the weighting percentage of firm k in mutual fund i.

STEP 3: Measurement of "transparency"

The next step consists in obtaining a set of weights which will play a correcting factor as they represent the degree of quality (in terms of transparency and credibility) of the information on the social screening process provided by the mutual funds' managers. They are given by the expert and they depend on several criteria: quality of the description of the screening process, existence of an external research team composed of experts in SRI, periodical non-financial audits, description of engagement policy, public disclosure of proxy voting practices and education of the fund manager on SRI practices. As we did with the degree of social responsibility of each firm k with respect to each screen j, we will assign each weight an interval inside [0, 1]:

$$\tilde{w}_i = \left\{(w_i, [b_{w_i}^L, b_{w_i}^U])\right\}, \quad 1 \leq i \leq n. \tag{14.6}$$

These weights will be also a discrete set. The interval represents the membership function of the weight assigned to mutual fund i considered as a tolerance interval.

STEP 4: Fuzzy Social Responsibility Degree

For each mutual fund F_i, its Fuzzy Social Responsibility Degree, $\widetilde{SRD}_i$, will be defined as:

$$\widetilde{SRD}_i = \tilde{w}_i \tilde{s}_i, \quad 1 \leq i \leq n, \tag{14.7}$$

and taking into account (14.5) and (14.6), its membership function is given by

$$\mu_{\widetilde{SRD}_i}(F_i) = [SRD_i^L, SRD_i^U] = [b_{w_i}^L, b_{w_i}^U] * [b_i^L, b_i^U] \\ = [b_{w_i}^L b_i^L, b_{w_i}^U b_i^U],\ 1 \leq i \leq n. \tag{14.8}$$

STEP 5: Expected Value of the Fuzzy Social Responsibility Degree

We will handle the Fuzzy Social Responsibility Degrees by means of their expected values (Heilpern 1992):

$$EV(\widetilde{SRD}_i) = \frac{1}{2}(SRD_i^L + SRD_i^U) = \frac{1}{2}(b_{w_i}^L b_i^L + b_{w_i}^U b_i^U), \quad 1 \leq i \leq n. \tag{14.9}$$

Example 14.2 Let us consider 10 large cap equity mutual funds from which 5 were members of the Social Investment Forum (SIF) at the end of 2007. Let us focus on the environmental dimension (see Table 14.1). Environmental fuzzy data have been obtained based on KLD binary database at 31-12-2007 incorporating the expert knowledge about the firms in terms of environmental responsibility.

We have considered KLD's 13 environmental qualitative screens which are related to: climate change and clean technologies, pollution and toxics and other environmental issues as recycling questions (see Table 14.2 for a description of applied screens). The environmental responsibility degree has been calculated for both, the so-called socially responsible mutual funds and the conventional mutual funds.

As described before, the expert based on his/her personal subjective knowledge, evaluates the environmental responsibility degree of each firm with respect to each of the environmental screens. In order to do this, KLD's binary scores are taken into account as well as the expert's knowledge about each firm and the particular characteristics of each screen.

Taking into account previous information the expert evaluates the quality of the screening process (see www.ussif.org).

Table 14.3 displays the evaluation of the environmental responsibility degree for each mutual fund. The first column indicates if the fund is socially responsible fund

Table 14.1 Selected funds

#	Name	#	Name
F1	Calvert Large Cap Growth A	F6	BlackRock Index Equity Inv A
F2	Calvert Social Investment Equity A	F7	Dreyfus Appreciation
F3	Domini Social Equity Inv	F8	JPMorgan Equity Index Select
F4	Green Century Equity	F9	Legg Mason Cap Mgmt All Cap B
F5	MMA Praxis Core Stock A	F10	MFS Blended Res. Core Equity A

Table 14.2 KLD's environmental screens

Screen		Screen	
$\tilde{s}_1$	Beneficial products and services	$\tilde{s}_8$	Regulatory problems
$\tilde{s}_2$	Pollution prevention	$\tilde{s}_9$	Ozone depleting chemicals
$\tilde{s}_3$	Recycling	$\tilde{s}_{10}$	Substantial emissions
$\tilde{s}_4$	Clean energy	$\tilde{s}_{11}$	Agricultural chemicals
$\tilde{s}_5$	Management systems	$\tilde{s}_{12}$	Climate change
$\tilde{s}_6$	Other strength	$\tilde{s}_{13}$	Other concern
$\tilde{s}_7$	Hazardous waste		

Source: KLD (2008)

Table 14.3 Mutual funds' fuzzy environmental responsibility degree

SR	Fund	b_i^L	b_i^U	$b_{w_i}^L$	$b_{w_i}^U$	SRD_i^L	SRD_i^U	$EV(\widetilde{SRD}_i)$
Y	F1	0.3574	1.795	0.2	0.4	0.0715	0.6527	0.3621
Y	F2	0.295	1.6667	0.2	0.4	0.059	0.6061	0.3325
Y	F3	0.746	2.727	0.3	0.5	0.224	1.736	0.98
Y	F4	0.274	2.185	0.1	0.4	0.082	0.993	0.538
Y	F5	0.25	1.649	0.3	0.4	0.025	0.6	0.312
N	F6	0.224	1.692	0	0	0	0	0
N	F7	0.752	2.61	0	0	0	0	0
N	F8	0.249	1.952	0	0	0	0	0
N	F9	0.315	1.943	0	0	0	0	0
N	F10	0.339	1.995	0	0	0	0	0

or not. As can be observed in the table, the degree of environmental responsibility of conventional mutual funds is zero. This is due to the fact that conventional mutual funds do not compromise themselves to the accomplishment of a socially responsible investment policy and thus, they can change their portfolio composition at any time investing in companies which are not socially responsible. So, although at a certain moment of time the environmental responsibility degree of the companies invested in by a conventional fund could be similar to the degree of the socially responsible funds, a penalizing weight equal to zero is applied to reflect the fact that there is no socially responsible investment policy behind the investment decisions of those mutual funds.

14.4 Portfolio Selection Under Cardinality and Semicontinuous Variable Constraints

The original Markowitz Portfolio Selection Model (Markowitz 1952, 1959) was very simple, mainly because computers could not handle more difficult instances. It just sought for the efficient portfolio corresponding to a desired expected return or to a maximum allowable risk. However, nowadays the available computational power is much greater and hence more sophisticated models can be dealt with, looking for efficient portfolios satisfying also additional constraints. There are many contexts in which such constraints become necessary. Some of them are related to the mutual fund management. Fund managers must comply with contractual requirements determined by the prospectus as well as with legal requirements, such as the 5-10-40-constraint imposed by the §60(1) of the German investment law (Bundesgesetzblatt 2003), which establishes that securities of the same issuer are allowed to amount to up to 5 % of the net asset value of the mutual fund, but they are allowed to 10 % if the total of all of these assets is less than 40 % of the net asset value. It is also usual to include buy-in thresholds to reduce transaction costs. This means not allowing the share of a portfolio in a given asset to be less than a certain amount. A third typical example is that managers often impose upper bounds to the total number of assets in a portfolio also to reduce transaction costs, as well as lower bounds in order to diversify the investment. See Horniman et al. (2001) for the computational aspects associated with these additional constraints.

In order to simplify the exposition, we restrict ourselves to a model containing the relevant constraints from a computational point of view. Other requirements that can be expressed just as additional linear constraints or as simple variations of the objective function (such as taxes, commissions or returns in form of dividends) will not be considered. Specifically, we will consider semicontinuous variable and cardinality constraints. Semicontinuous variable constraints appear in a natural way as a refinement of bound constraints, since in many cases the investor does not really wish to force each asset to have a minimum weight in the portfolio. However, in order to avoid an excess of diversification in the optimal portfolio, he may wish to require a minimum weight for those assets actually appearing in it. To deal with semicontinuous variables, we introduce binary variables y_i taking the value 1 if the i-th asset appears in the portfolio and 0 otherwise. Hence the basic model is the following variant of the basic Markowitz problem:

$$\begin{aligned} \text{Min. } & R = x^t V x \\ \text{s.t. } & e^t x \geq r \\ & 1^t x = 1 \\ & l_i y_i \leq x_i \leq u_i y_i, \quad 1 \leq i \leq n \\ & y_i \in \{0, 1\}, \end{aligned} \tag{14.10}$$

where l_i and u_i are the minimum and the maximum values allowed for the weights in the portfolio. The cardinality constraints can be imposed as conditions over the variables y_i. The simplest case is:

$$m \leq \sum_{i=1}^{n} y_i \leq M. \tag{14.11}$$

Semicontinuous variable constraints make the efficient frontier more complicated because the original quadratic continuous problem becomes a mixed integer quadratic problem. In this case, the efficient frontier can be viewed as the pointwise minimum of the set of the efficient frontiers of the continuous quadratic subproblems resulting from (14.10) by fixing each possible set of values for the binary variables y_i.

Consider for instance the 5-variable problem determined by Table 14.4. We set bounds $\mathbf{l} = (0.2, 0.3, 0.2, 0.3, 0.2)$, $\mathbf{u} = (0.6, 0.6, 0.6, 0.6, 0.6)$ and the cardinality constraint (14.11) with $m = 2$, $M = 5$. Hence, this particular instance of (14.10) determines 27 subproblems whose efficient frontiers are shown in Fig. 14.3. Then the efficient frontier is that shown in Fig. 14.4. Notice that we have extended each efficient frontier with an initial vertical line. This is useful for calculating their pointwise minimum.

More precisely, if we call P_y the quadratic problem resulting from (14.10) by setting the binary variables equal to y, the efficient frontier of P_y can be parametrized by a continuous piecewise parabolic function $R_{\mathbf{y}} : [r^1_{\mathbf{y}}, r^2_{\mathbf{y}}] \longrightarrow \mathbb{R}$, where $R_{\mathbf{y}}(r)$ is the risk corresponding to an expected return r, and we can calculate

$$r_{\min} = \min_{\mathbf{y}} r^1_{\mathbf{y}}, \qquad r_{\max} = \max_{\mathbf{y}} r^2_{\mathbf{y}}$$

Table 14.4 Returns on five assets (Markowitz 1952)

Year	AmT	ATT	USS	GM	ATS
1937	−0.305	−0.173	−0.318	−0.477	−0.457
1938	0.513	0.098	0.285	0.714	0.107
1940	0.055	0.2	−0.047	0.165	−0.424
1941	−0.126	0.03	0.104	−0.043	−0.189
1942	−0.003	0.067	−0.039	0.476	0.865
1943	0.428	0.3	0.149	0.225	0.313
1944	0.192	0.103	0.26	0.29	0.637
1945	0.446	0.216	0.419	0.216	0.373
1946	−0.088	−0.046	−0.078	−0.272	−0.037

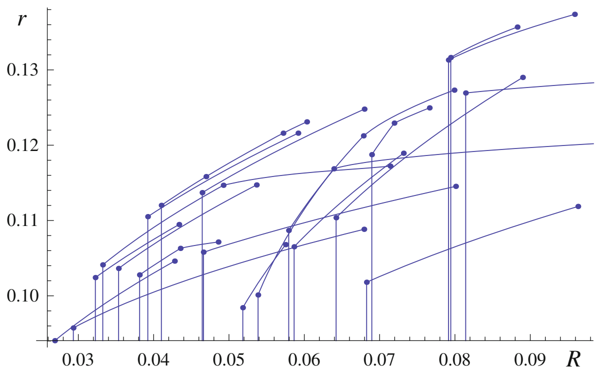

Fig. 14.3 Efficient frontiers of the subproblems for a five-asset instance of (14.10)

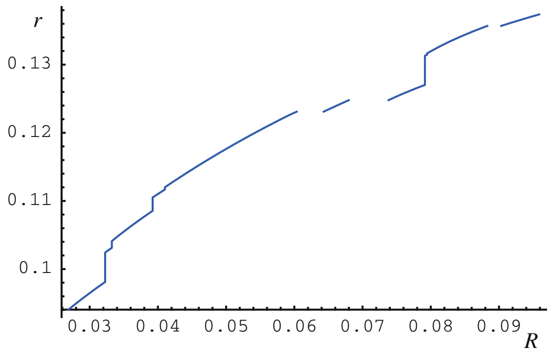

Fig. 14.4 Efficient frontier of the same instance of (14.10) considered in Fig. 14.3

and extend each $R_{\mathbf{y}}$ to $\bar{R}_{\mathbf{y}} : [r_{\min}, r_{\max}] \longrightarrow \mathbb{R}$ given by

$$\bar{R}_{\mathbf{y}}(r) = \begin{cases} R_{\mathbf{y}}(r_{\mathbf{y}}^1) \text{ if } r < r_{\mathbf{y}}^1, \\ R_{\mathbf{y}}(r) \;\; \text{if } r_{\mathbf{y}}^1 \leq r \leq r_{\mathbf{y}}^2 \\ M \qquad \text{if } r_{\mathbf{y}}^2 < r, \end{cases}$$

where M is a real number greater than any value attained by any of the functions $R_{\mathbf{y}}$. This extension allows us to define $R : [r_{\min}, r_{\max}] \longrightarrow \mathbb{R}$ as

$$R(r) = \min_{\mathbf{y}} \bar{R}_{\mathbf{y}}(r).$$

In Calvo et al. (2012) a method is presented for computing the function $R(r)$ of medium-sized instances of (14.10).

14.5 A Soft Computing Approach to SRI

In the literature many fuzzy versions of the portfolio selection problems can be found. Several authors apply possibility distributions to model uncertainty (see for instance, Tanaka and Guo 1999; Inuiguchi and Ramik 2000; Tanaka et al. 2000; Zhang et al. 2007). Besides Arenas-Parra et al. (2006) use fuzzy compromise programming and Watada (1997) introduces vague goals. Further, Lacagnina and Pecorella (2006) combine stochastic and fuzzy techniques.

Here we describe a method to select socially responsible portfolios subject to the financial constraints described in the previous section. In order to illustrate the procedure we consider a simple case in which the investor must select a portfolio from 10 possible mutual funds given in Table 14.3, which also contains in its last column the fuzzy evaluation of their environmental responsibility degree calculated as described in Sect. 14.3. The vector of expected returns is

$$\mathbf{e} = (0.275, 0.213, 0.062, 0.082, 0.007, 0.099, 0.094, 0.644, 0.519, 0.394).$$

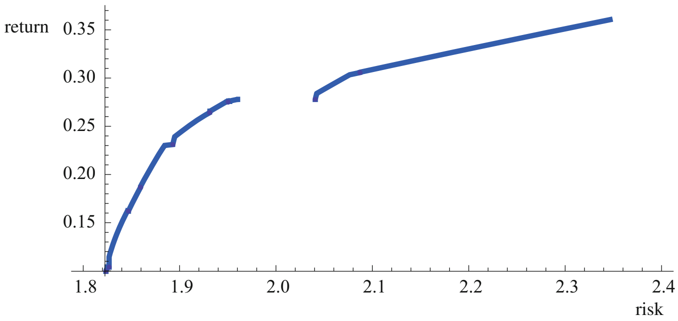

Fig. 14.5 Efficient frontier of the considered instance of (14.10)

For the sake of brevity we omit the variance-covariance matrix and the vector of expected returns. We are using weekly data from 31-12-2006 to 31-12-2007 provided by Morningstar Ltd. Assume we wish to select a portfolio consisting of a minimum of 3 and of a maximum of 6 funds in such a way that each non-zero weight is at least 0.05. As upper bounds for the weights, we fix 0.25 for the first five (the socially responsible ones) and 0.15 for the conventional ones. These weights allow up to 75 % of conventional funds and up to 100 % of socially responsible funds in each feasible portfolio. These values determine the following instance of (14.10) whose efficient frontier is that shown in Fig. 14.5. We remark that the risk represented in the figures is the standard deviation $\sqrt{x^t Vx}$ instead of the covariance, which makes risk variations directly comparable to return variations.

$$\begin{aligned} \text{Min. } & \mathbf{x}^t \mathbf{V}\mathbf{x} \\ \text{s.t. } & \mathbf{e}^t \mathbf{x} \geq r \\ & \mathbf{1}^t \mathbf{x} = 1 \\ & 3 \leq \sum_{i=1}^{10} y_i \leq 6 \\ & 0.05 y_i \leq x_i \leq 0.25 y_i,\ 1 \leq i \leq 5 \\ & 0.05 y_i \leq x_i \leq 0.15 y_i,\ 6 \leq i \leq 10 \\ & y_i \in \{0, 1\}, \end{aligned} \tag{14.12}$$

By observing the efficient frontier, the investor can choose the zone of the risk-return plane he is interested in. Figure 14.6 shows the efficient frontiers of the subproblems P_y with a part in common with the global efficient frontier, and we will assume that the investor is interested in the region inside the rectangle.

We can see that two portfolios can be very similar with regard to risk and return but have significant differences about their composition that can be relevant to the investor. Hence the investor could prefer the non-efficient composition beneath the efficient one if it suits better his secondary preferences. However, there is no reason to restrict ourselves to compositions that are efficient at some interval. Figure 14.7 shows all the possibilities that are efficient for a fixed composition. It is clear that

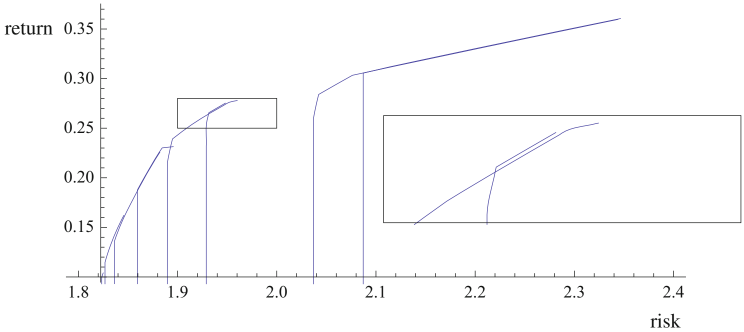

Fig. 14.6 Efficient frontiers of the quadratic problems comprising the efficient frontier of Fig. 14.5 together with a zoom of the region of risk and returns that the investor considers acceptable

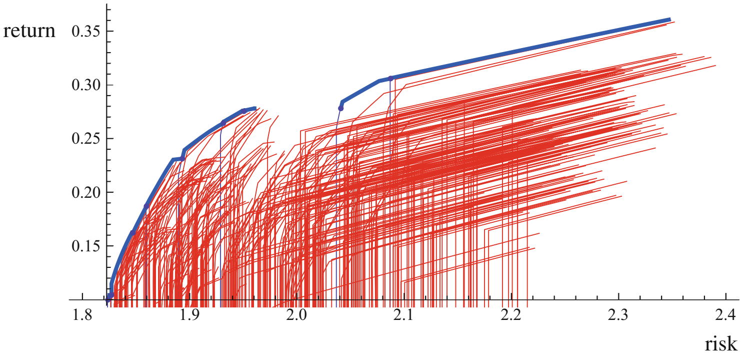

Fig. 14.7 Efficient frontiers of all the subproblems corresponding to all possible portfolio compositions in the example

many of them are not interesting, but our proposal is to ask the investor to choose a fuzzy section around a point of the efficient frontier and consider all the subefficient compositions inside. In this example we are considering, there are 330 feasible subproblems. These subfrontiers are easily calculated by the techniques described in Calvo et al. (2012), but we insist that it is not necessary to compute all of them for our purposes.

Figure 14.8 shows the risk-return pairs that the investor is willing to consider regarding the financial objectives. It contains just 13 fragments of subefficient frontiers. This implies that each (efficient or not) feasible portfolio of any subproblem different from the 13 appearing in that region must be discarded, and we want to seek the best portfolios within the selected region according to both financial and CSR criteria, favoring the latter but also taking into account the former. Let us see how fuzzy set theory provides us with the appropriate tools for selecting portfolios this way.

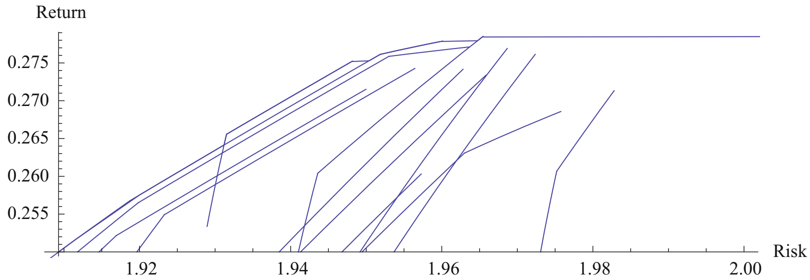

Fig. 14.8 Efficient frontiers of the subproblems within the region selected by the investor

Our constraint set will be a subset of the set

$$X = \{(x, y) \in [0, 1]^n \times \{0, 1\}^n \mid 1x = 1, m \leq 1y \leq M,\ l_i y_i \leq x_i \leq u_i y_i\}, \tag{14.13}$$

so that each partially feasible portfolio must satisfy the hard constraints of the problem. The totally feasible portfolios will be those that the investor is willing to accept with regard to their expected return and their risk, and the degree of feasibility (i.e. the degree of membership of the feasible set $\tilde{C}$) goes to zero as long as the pair (r, R) of return and risk becomes unacceptable. Notice that we do not require totally or partially feasible portfolios to be efficient. On the contrary, a non-efficient portfolio can be acceptable or even preferable for the investor if it is good enough with regard to a secondary goal.

A more specific definition of the feasible set $\tilde{C}$ could be $\tilde{C} = \tilde{C}_r \cap \tilde{C}_R$, where the membership functions of the fuzzy sets $\tilde{C}_r$ and $\tilde{C}_R$ are given by:

$$\mu_{\tilde{C}_r}(x, y) = \begin{cases} 1 & \text{if } r \geq r_0, \\ \frac{r - r_0 + s_r}{s_r} & \text{if } r_0 - s_r < r < r_0, \\ 0 & \text{if } r \leq r_0 - s_r, \end{cases}$$

$$\mu_{\tilde{C}_R}(x, y) = \begin{cases} 1 & \text{if } R \leq R_0, \\ \frac{R_0 + s_R - R}{s_R} & \text{if } R_0 < R < R_0 + s_R, \\ 0 & \text{if } R \geq R_0 + s_R, \end{cases}$$

where r and R are respectively the expected return and the risk of the portfolio (x, y) and the values r_0, R_0, s_r and s_R are determined from the investor's preferences. This means that r_0 and R_0 are an expected return and a risk that the investor considers as completely acceptable, but he would accept worse values until reaching the tolerances s_r and s_R if this provides better results for the secondary goal.

Next we define a fuzzy goal set $\tilde{G}$ from two auxiliary fuzzy sets $\tilde{E}$ and $\tilde{S}$, the first one defining the "efficient enough" portfolios and the second one defining the "good enough" ones with regard to the secondary goal (always according to the investor's preferences). Set $\tilde{E}$ will express what we are losing by accepting a non-efficient portfolio, and so efficient portfolios will be now the totally efficient ones, i.e. those having degree of membership of $\tilde{E}$ equal to 1.

First we define efficiency with regard to the expected return, and then the efficiency with regard to the risk by means of two fuzzy sets $\tilde{E}_r$ and $\tilde{E}_R$. The membership of $\tilde{E}_r$ is:

$$\mu_{\tilde{E}_r}(x, y) = \begin{cases} 1 - \frac{r_{\text{ef}}(R) - r}{t_r} & \text{if } r \geq r_{ef}(R) - t_r, \\ 0 & \text{otherwise,} \end{cases}$$

where t_r is a tolerance determined from the investor's preferences and $r_{\text{ef}}(R)$ is the efficient expected return corresponding to the risk R of the portfolio (x, y). This means that the degree of efficiency with regard to the expected return reaches the value 0 when the difference between the expected return r of the portfolio and $r_{\text{ef}}(R)$ exceeds a tolerance fixed by the investor.

Analogously, we define the membership function of $\tilde{E}_R$ as

$$\mu_{\tilde{E}_R}(x, y) = \begin{cases} 1 - \frac{R - R_{\text{ef}}(r)}{t_R} & \text{if } R \leq R_{ef}(r) + t_R, \\ 0 & \text{otherwise,} \end{cases}$$

which means that the degree of efficiency of a portfolio with regard to the risk is 1 for efficient portfolios and reaches the value 0 when the difference between the risk R of the portfolio and the efficient risk $R_{\text{ef}}(r)$ for its return r exceeds a given tolerance t_R.

Now we define $\tilde{E} = \tilde{E}_r \cap \tilde{E}_R$, where the membership function of the fuzzy intersection is defined as the minimum of the previously defined membership functions. Hence the set $\tilde{E}$ allows us to speak about partially efficient portfolios in such a way that efficient portfolios in the usual sense are now the totally efficient ones, but a portfolio close enough to the efficient frontier is considered as "almost efficient" in the fuzzy sense.

At this point we introduce the investor's preferences on the secondary goal. Let us assume that these preferences are given by a fuzzy set $\tilde{S}$, i.e., the membership degree of $\tilde{S}$ indicates "how good" a given portfolio is with regard to CSR. Specifically, we can define the *Social Responsibility Degree* of a portfolio as

$$\text{SRD}(x) = \sum_{i=1}^{n} \text{sr}_i x_i,$$

and then normalize it as

$$\mu_{\tilde{S}}(x, y) = \frac{\text{SRD}(x)}{\text{MSRD}},$$

where SRD is the maximum value that MSRD(x) attains on the set X defined in (14.13), which can be calculated by solving a linear problem.

Then we define our fuzzy goal set $\tilde{G}$ by means of the membership function as a weighted sum

$$\mu_{\tilde{G}}(x, y) = w\mu_{\tilde{S}}(x, y) + (1 - w)\mu_{\tilde{E}}(x, y),$$

where the weight w expresses the importance of the secondary goal for the investor with regard to efficiency. So, a high value for w means that the investor is willing to go relatively far from the efficient frontier in order to obtain higher values of $\mu_{\tilde{S}}$, whereas a small value of w means that the investor wishes to stay near the efficient frontier. In any case, recall we have defined the feasible set in such a way that only good enough solutions with regard to the financial goals are under consideration, and so the financial goals are always the main goals of the problem. More specifically, a large value for w means that, among the acceptable solutions with regard to the financial goals, those best with regard to $\tilde{S}$ are preferred, and only for similar values with regard to $\tilde{S}$ the degree of efficiency becomes relevant.

All in all, the degree of membership of the decision set is given by

$$\mu_{\tilde{D}}(x, y) = \min\{\mu_{\tilde{C}}(x, y), w\mu_{\tilde{S}}(x, y) + (1 - w)\mu_{\tilde{E}}(x, y)\}$$

and the fuzzy problem (FP) is the problem determined by this decision set, whose optimal solutions are those with maximum degree of membership of $\tilde{D}$:

$$\begin{aligned}
\text{(FP) Max. } & \min\{\mu_{\tilde{C}}(x, y), w\mu_{\tilde{S}}(x, y) + (1 - w)\mu_{\tilde{E}}(x, y)\} \\
\text{s.t. } & 1x = 1 \\
& m \le \textstyle\sum_i y_i \le M \\
& l_i y_i \le x_i \le u_i y_i, \qquad i = 1, \ldots, n \\
& x_i \ge 0,\ y_i \in \{0, 1\} \quad i = 1, \ldots, n
\end{aligned}$$

In order to apply these ideas to our example, we see that the feasible region shown in Fig. 14.8 is determined by the pair $(r_0, R_0) = (0.26, 1.98)$ with tolerances $(s_r, s_R) = (0.01, 0.02)$. In order to define the fuzzy set $\tilde{E}$ determining the partially efficient portfolios, we must fix the tolerances (t_r, t_R). In absence of a concrete investor to adopt a more specific criterion, a default choice could be taking as t_r the maximum distance from a return in the efficient frontier to the minimum return in the feasible region, and analogously for t_R. In our case: $t_r = 0.2785–0.25 = 0.0285$ and $t_R = 2 - 1.9093 = 0.0907$.

To determine an instance of the problem (FP), we need to fix the weight w for the social responsibility degree in the goal function. Let us set quite a high value, namely $w = 0.8$ to favor those portfolios being quite far from the efficient frontier if they are good with regard to SRI.

The optimal solution of (FP) is the portfolio N1 in Table 14.5, whose degree of membership of the decision set is 0.6262. With this solution, the investor gets

Table 14.5 The six best solutions for different portfolio compositions

	Portfolio										$\mu_{\tilde{D}}$	SRD	Return	Risk
N1	0.23187	0.25	0.218134	0	0	0	0	0	0.1	0.15	0.6262	0.3808	0.268	1.98
N2	0.20585	0.25	0	0.25	0	0	0	0	0.14415	0.15	0.6250	0.2922	0.264	1.931
N3	0.25	0.25	0.15	0.05	0	0	0	0	0.15	0.15	0.6185	0.3476	0.272	1.973
N4	0.16669	0.25	0	0.23331	0	0.05	0	0	0.15	0.15	0.5913	0.2690	0.26	1.924
N5	0.16803	0.25	0	0.23197	0	0	0.05	0	0.15	0.15	0.5818	0.2688	0.26	1.926
N6	0.25	0.25	0.15	0	0	0.05	0	0	0.15	0.15	0.5803	0.3207	0.273	1.978

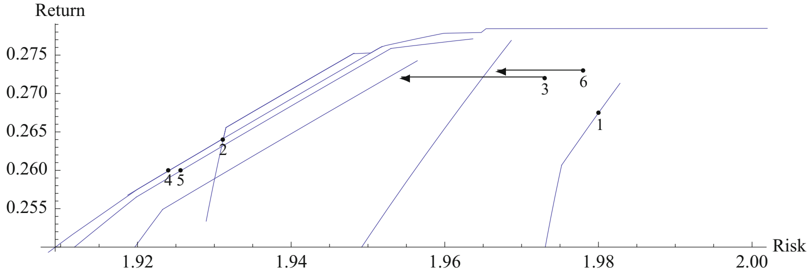

Fig. 14.9 Location on the risk-return plane of the best solutions and the efficient problem of the corresponding subproblems. The *arrows* indicate the efficient frontiers of the subproblem to which they belong

an expected return $r = 0.258$, with a risk $R = 1.98$ and a social responsibility degree $s = 0.3808$. In Fig. 14.9 we can see its position (marked as 1) in the risk-return plane. We see that it is quite far from the efficient frontier. It is interesting to compare this optimal solution with other alternatives, and therefore Table 14.5 contains the six best portfolios that are optimal with regard to the portfolios with the same composition. Notice that this does not mean that portfolio N2 is the second best solution of (FP), since there are infinitely many portfolios near N1 that are better than N2. What we can say is that, if we look for a portfolio with a composition different from that of N1, the best possibility is N2, and so on.

Figure 14.9 shows the position of the portfolios appearing in Table 14.5 in the risk-return plane. We see that N2 is completely efficient. When compared to N1, it has a similar expected return, a substantially better risk, but a significantly lower social responsibility degree. By contrast, portfolio N3 is again a good solution with regard to social responsibility (it has the second best SRD), but it is worse than N1 because of its SRD, and worse than N2 because of its significantly lower degree of efficiency.

Let us also remark that N1 is not completely efficient, but it is an efficient portfolio of its subproblem, namely, that corresponding to the composition $y = (1, 1, 1, 0, 0, 0, 0, 0, 1, 1)$. However, N3 is quite far from the efficient frontier of its subproblem (which is that indicated in Fig. 14.9 with an arrow). The same holds for portfolio N6. This shows that in order to solve (FP) we cannot restrict ourselves to efficient solutions of the associated subproblems.

In general, when applying a heuristic procedure for solving a larger instance of (FP), it is useful to save not only the best portfolio along the search process, but the best portfolio found for each composition. Hence, in the end we can present the investor not only with the optimal portfolio, but also with a list of alternatives for different compositions. These alternatives are ordered a priori according to his own preferences. In this way the investor is given a last chance to decide which portfolio suits better his preferences with regard to the trade off between risk, return and social responsibility.

Conclusions

In this chapter we have described two applications of fuzzy set theory to socially responsible portfolio selection. The first one provides a technique to accurately reflect the available information, expert opinions and investor's judgements about the set of mutual funds from which the portfolio is to be selected. The second one is a fuzzy model which provides a criterion for selecting alternative portfolios not too far away from the efficient frontier but that can fit better a desired fuzzy trade-off between financial and socially responsible goals. One of the main advantages of the proposed method is that the investor always knows the financial cost of the proposed socially responsible alternatives, in the sense that the distance to similar efficient portfolios is known and this distance is constrained according to the investor's preferences. We have seen in the example that if we provide the investor with the best alternatives for different possible portfolio compositions, we obtain a set of diverse portfolios, both with regard to financial efficiency and social responsibility, better fitting his or her preferences.

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